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EDITORIAL.

The Construction of Iron Vessels.—Some discussion has followed the announcement that the large steamers recently built for the Pacific Mail Steamship Company had developed such weakness as to require extensive reconstruction.

It is generally known to engineers, that similar occurrences have befallen many of the iron ships, both foreign and American, but advertisement of these, not being demanded for stock-jobbing purposes, has not generally ensued.

In fact, the public interest is not so very great. Not one voyage in five thousand terminates in "never heard from," nor does one in fifty of the shipwrecks, which are happily very few when compared with the number of safe voyages, allow the catastrophe of final breaking up to be attributed to original defect.

The real parties primarily involved are the insurance companies and the owners, and the insurance companies can and do submit to some loss. If there were no risk, no one would insure. It is better to pay losses on damage to cargo or vessel, and to permit compara-

tively unsafe vessels to run, than to throw the loss on owners until they should elevate the character of their vessel above insurance, or if insured, to enable them to cut down the premium to small percentage. Owners, on their side, look to the first outlay. Ships in Scotland, as well as in the United States, are built for the least money possible, and the least money means the least material. The insurance companies, by two codes, one English, "Lloyd's," and the other French, "le Bureau Veritas," have established the least dimensions of parts they will take their *chance* upon, and the builders are openly instigated by the owners to compete for how near those rules, not to say how much below them, he will work. Some specious reason, such as the extra strength of American iron (overlooking the equality of meanness), will be found for *coming very close* in thicknesses, besides taking every advantage of the exact specification. The lowest price will get the job, and both owner and insurance company (the builder, perhaps not altogether avoiding his share), will assume the risk. If no storms intervene, and good luck waits the craft, she will float a long existence with high reputation to all. There are vessels built on all hands for the best possible, but in Scotland, as well as here, not at the price. The best Scotch builders must have £30 to £32 10*s*. per ton, for outfitted steamers, and the Cunards' are said to have paid in excess of £32 10*s*., while ships have been built for £22 10*s*.

It may seem a very low standard for iron ship-building, that the willingness to provide cheap work should exist. But the popular idea of enterprise is found in undertaking as the lowest bidder, and the result has broken, one by one, the larger engine shops of the country on the wheel of competition. So far as vessels are concerned, it would be a consolation if the loss from departure from those rules of purchase which alone give right to excellence, to wit, paying for it, fall mainly on the owners or insurers, but, unfortunately, the life of our great workshops is involved in this abuse of the contract or competitive system.

The attempt to secure excellence by specification, or even supervision, is as futile as the attainment of high morality by the law and the constable.

Water Supply Commission.—We learn that the labors of this Commission are drawing to a close, and that their report to the Mayor and Councils of this city is to be presented at the close of the present month. [It will be recollected that the engineers comprising this

Commission were selected by the Mayor from a list furnished, by request of Councils, by the Franklin Institute, and that one of the nominees, Mr. Fairman Rodgers, of Philadelphia, having declined to serve, his place was filled by the appointment of Col. Julius W. Adams, Chief Engineer of the Brooklyn Water Works, all being afterward unanimously confirmed by Councils.]

The Commission consists of Mr. W. Milnor Roberts, of New York, Chairman, Hon. Wm. J. McAlpine, of Albany, Col. Julius W. Adams, of Brooklyn, and Messrs. Wm. E. Morris and S. W. Roberts, of Philadelphia, in conjunction with Dr. Wm. H. McFadden, Chief Engineer of the Water Department. These gentlemen, when not in the field engaged in examining the various works, sources of supply, routes for proposed conduits, canals, reservoirs, and pumping stations, etc., have held their sessions in one of the rooms of the Franklin Institute, which was placed at their disposal for that purpose.

As the report of these gentlemen is not yet written, and when ready will first go to the Mayor and Councils, previous to being given to the public, we are of course unprepared to say anything respecting its views and recommendations, whatever these may be. We know that the subject is one of great importance, in which all the citizens of Philadelphia are naturally specially interested. Our city is growing so rapidly, and so largely in the direction of manufactures of every description, that a pure and abundant supply for its present and future wants is obviously a prime necessity.

The whole subject of the present and future water supply of our city has, during many years, received so much intelligent attention, that in the nature of the case not much room has been left for originality at the present day, respecting the sources of supply and general methods of introducing water to this large and growing metropolis; but an ample field of investigation still remained open in regard to the comparative merits of different schemes, the selection of the best source or sources of supply, the proper mode of bringing the water to a convenient centre of distribution, of preserving its purity, and securing a satisfactory delivery to the consumers. It is reasonable to presume that a commission of disinterested experts, selected as these gentlemen were on account of their known experience and engineering judgment, would not only give to the study of the questions involved the benefit of their experience, but that they would be able to present their views in such shape as to entitle them to the most

careful consideration, not only of the Mayor and Councils, but of the citizens of Philadelphia generally.

It would indeed be remarkable, if Philadelphia, situated as she is between two large rivers of fresh water, should not have it in her power to secure for her future growth, great as that may and probably will be, an ample supply of pure water.

There need be no doubt on that score, yet it still remains an open question as to what may be the most advisable course for the city to pursue in connection with our present water supply system, its immediate requirements and its unavoidable future extension. The water supply demands of modern cities, from various causes, increase in a greater ratio than that of the mere augmentation of population; and although this may be somewhat changed hereafter by the introduction of satisfactory means of avoiding waste, yet it is probable that it may always be true, especially in manufacturing cities.

When the Croton Aqueduct to supply New York was constructed, about a third of a century ago, the quantity of water it could furnish was deemed to be sufficient for a population of nearly or quite two millions of persons; yet it is already inadequate, and the city is at this very time, devising means of increasing the supply, which at present is about one hundred and ten million gallons per day, with a population of a little over one million. This shows a much larger supply per capita than is usually considered necessary even in manufacturing cities. It would appear to betoken waste, or a large consumption by the use of fountains. The period is probably close at hand when the City of Philadelphia will contain a population of over a million, and in view of that fact, and of its continued rapid increase, both in the number of inhabitants and in the extent and variety of its manufactories, the water supply has become a question of paramount importance, and it should, and doubtless will, always command the most careful attention and consideration of the representatives and executive officers of our city.

Special provision having already been made by the Centennial Commission for an additional supply of water for the Centennial grounds and buildings, no fears need be apprehended on that score; and if the city authorities should be prompt in carrying out the recommendations of the Water Supply Commission, there should remain no reasonable ground of complaint during the Centennial year, concerning the quantity and quality of the water supply in Philadelphia.

Improvement of Hell Gate Channel, New York —The Government works at Hallett's Point have reached their last stage of progress, but it will be nine months or more before the great explosion will take place. The excavations were completed about two months ago. They undermine a surface of 2¼ acres, and extend in headings and galleries 315 feet from land. The headings are the straight cuttings radiating from the shaft; they are 10 in number at the shaft and 41 in number at the outer edge of the semicircle. The galleries, 10 in number, are arcs of circles connecting the headings. The cuttings of both kinds aggregate 7,542 feet in length; they are from 12 to 13 feet wide, and from 8 to 22 feet high. Over their lowest point they are 53 feet below water. They leave a roof of solid rock 10 feet thick between the mine and the water. Over the outer edge of the excavation the water of the river is 26 feet deep at low tide.

At the intersection of the headings and galleries, columns or piers are left standing, by which the roof is supported. These number 172. The work of the final demolition of the reef will consist in breaking up these piers and shattering the rocky roof. Preparations for this are now in progress. Holes are being bored by steam drills in the piers and roof, into which charges of nitro-glycerine will be put, and all will be exploded at the same instant. There will be from 10 to 15 two and three inch holes in each column; and in the roof there will be three-inch holes about five feet apart. The charges of nitro-glycerine will average from 8 to 10 pounds, and all will be connected by gas-pipe filled with the same explosive. The nitro-glycerine in the pipe being fired by a friction battery, the charges will be exploded by concussion. Experiments have been tried under the direction of Government officials in regard to this method of exploding the charges, and the officers in command have no doubts as to successful results. At Mountain View, New Jersey, 2,000 charges were fired in this manner, and it is said that it was shown that there is no limit to the number which may be exploded simultaneously.

The final boring is less than half completed, and will occupy from two to three months more. It will take two months longer to charge the holes with nitro-glycerine, and the officers will wait till warm weather before firing the mine. Nitro-glycerine freezes at about 40° and is then practically inexplosive and safe to handle. The charges will be put in place during the winter, and will thaw out during the early summer. Before electricity is applied the water will be let in.

This will act as "tamping" and cause the explosion to be more effective. It is claimed that if only half the charges take fire, the work will be thoroughly accomplished.

The time for making the final attempt has not yet been fixed upon, but it is probable, for reasons connected with the annual appropriations, it will be soon after the 30th of June of next year. The work has been in progress six years—since 1869—having been delayed (and prosecuted at much greater cost,) because of the inadequacy of the sums of money voted from time to time, to allow continued and vigorous prosecution.

A further improvement at Flood Rock has been in progress about three months, and a shaft has been sunk about 50 feet in the solid stone. The same system will be pursued here as at Hallett's Point; but the excavations will be much greater in extent, as the rock stretches out about 400 feet in two directions from the shaft. No estimate can be made of the time it will take to complete this work, as it depends chiefly on the appropriations made by Congress. The removal of the reef at Hallett's Point will greatly reduce the dangers of the Hell Gate passage, and be a permanent advantage to commerce even before the second enterprise is brought to a successful conclusion.—*From the N. Y. Tribune, Sept.* 5, 1875.

The American Association for the Advancement of Science, on Weights and Measures.—The special committee of this association, to which this subject was referred, report upon the steps taken the past year for the establishment and perpetuation of the basic units of the metric system, and the results of the conference of delegates from twenty-one nations. The United States was represented by Prof. Joseph Henry, of the Smithsonian Institute, and Julius G. Hilyard, of the Coast Survey (now President of the association). The original standard meter and kilogram were adopted, and steps taken for authentic reproduction of them for distribution, and for comparison with other standards of dimension or quantity. The report comments upon and lauds the co-operation of our executive government in this great effort for universal civilization, and asks from all scientific bodies an expression of opinion to urge upon Congress the monetary aid desirable to meet the national share of the expenses; estimating the same at $12,000 original appropriation, with about $1,000 per annum subsequently. The committee say: "It is to be considered, that this is not designed merely to advance the

interests of the metric system of weights and measures, or to serve as a means of promoting the extension of that system. The design is higher than that. To secure the universal adoption of the metric system, would be undoubtedly to confer an immense and incalculable benefit upon the human race; but it would be a benefit felt mainly in the increased facilities which it would afford to commerce, and to exactness in matters that concern the practical life of humanity. On the other hand, to secure that severe accuracy in standards of measurement which transcends all the wants of ordinary business affairs, yet which, in the present advanced state of science, is the absolutely indispensable condition of higher progress, is an object of interest to the investigators of nature immensely superior to anything which contemplates only the increase of the wealth of nations. * * *"

A series of resolutions were offered by the committee, and were unanimously adopted by the association. Those of our readers who are interested especially in the metric system, will find this report in full in the proceedings of the association, which will shortly be published.

Franklin Institute.

HALL OF THE INSTITUTE, Sept. 15th 1875.

The stated meeting of the Institute was called to order at 8 o'clock P.M., Vice-President B. H. Moore in the chair. There were 278 members and a number of visitors present.

The minutes of the stated meeting for June were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that since their meeting in June there had been 26 persons elected members of the Institute, and the following donations made to the library:

Memoirs of the Geological Survey of India. Vol. X, Part 2, Vol. XI, Part 1.

Records of the Geological Survey of India, Vol. VII, Parts 1 to 4.

Memoirs of the Geological Survey of India (Palæontologia Indica) being figures and descriptions of the Organic Remains procured dur-

ing the progress of the Geological Survey of India. Vol. I, 1. From the Superintendent of the Geological Survey of India, Calcutta, India.

Circulars of Information of the Bureau of Education, Nos. 1 and 2. Washington, 1875. From the Bureau of Education.

Transactions of the American Philosophical Society for promoting useful knowledge. Philadelphia. Vol. XV, new series, part 2. From the Society.

Reports of Scientific Investigations in relation to Sugar and Hydrometers, made under the superintendence of Prof. A. D. Bache, by Prof. R. S. McCullough. Washington, 1848. From the Secretary of the Senate.

List of Elevations, principally in that portion of the United States west of the Mississippi River, by Henry Gannett, M.E. Washington. From the Department of the Interior.

Bulletin of the United States' Geological Survey of the Territories. No. 4, second series. Washington. From the Department of the Interior.

Paine's British Palladio, or the Builder's General Assistant, etc., etc., by Wm. and Jas. Paine. Philadelphia. From Mr. Wm. W. Jefferies,

Geological Survey of Pennsylvania, 1874. Special report on the Petroleum of Pennsylvania, its production, transportation, manufactures and statistics, by H. E. Wrigley, with maps, etc., by D. Jones Lucas, and also map and profile of a line of levels along Slippery Rock Creek, by J. B. Lesley. Harrisburg, 1875. From the Board of Commissioners,

Second Geological Survey of Pennsylvania, 1874. Preliminary report on the mineralogy of Pennsylvania, by F. A. Genth, with an appendix on the hydrocarbon compounds, by Samuel P. Sadtler. Harrisburg, 1875. From the Board of Commissioners,

Circular No. 8, War Department, Surgeon-General's Office, Washington, May 1st, 1875. A report on the hygiene of the United States' Army, with descriptions of military posts. Washington, 1875. From the Surgeon-General, U. S. A.

Annual Report of the Auditor General of the State of Pennsylvania, and of the tabulations and deductions from the reports of the railroad, canal, and telegraph companies, for the year 1874. Harrisburg, 1875. From Wm. McCandless, Secretary Internal Affairs.

Bulletin of the National Association of Wool Manufacturers, 1875. From the Association.

Official Reports of Various Departments in the Vienna Exposition, 1873. From the Ministry of Foreign Affairs.

Supplements (No. 4) to the Seventh Annual Report of the Department of Marine and Fisheries, being for the fiscal year ended 30th June, 1874.

Reports of the Meteorological, Magnetic and other Observatories of the Dominion of Canada, for the calendar year ended 31st December, 1874. Toronto, Canada. From G. T. Kingston, Sup. Meteorological Office.

Minutes of Proceedings of the Institution of Civil Engineers, with other selected and abstracted papers, vol. 40, Session 1874–5, Part 2, by Jas. Forrest, Asso. Inst., C. E. Secretary. London, 1875. From the Institution.

Abstracts and Results of Magnetical and Meteorological Observations at the Magnetical Observatory, Toronto, Canada, from 1841 to 1871, inclusive. From G. T. Kingston, M.A., Director Mag. Observ.

Notes on Building Construction, arranged to meet the requirements of the Syllabus of the Science and Art Department of the Committee of Council on Education, South Kensington. Part 1, Stage or Elementary Course. London, 1875. From J. B. Lippincott & Co., Philadelphia.

By-Laws, Rules and Regulations, together with Reminiscences of the Carpenters' Hall, etc., etc. Philadelphia, 1873. From Carpenters' Co.

The American Ephemeris and Nautical Almanac, for the year 1878. From Prof. J. H. C. Coffin, U. S. N.

Report of the Board of Health of the City and Port of Philadelphia, to the Mayor, for the year 1874. From John E. Addicks.

Practical Guide to the Determination of Minerals by the Blowpipe, by Dr. C. W. C. Fuchs, edited by T. W. Danby, London. From the Author.

Hand-Book of Land and Marine Engines, by Stephen Roper. Philadelphia, 1875. From Claxton, Remsen & Haffelfinger, Publishers.

Practical Hints on Selection and Use of the Microscope, by John Phin. New York, 1875. From the Industrial Publication Co.

Principles of Metal Mining, by J. H. Collins. New York. From the Publishers.

General Index of the Official Gazette, and Monthly Volumes of Patents of the United States Patent Office, for 1874. Washington. 1875. From the Commissioner of Patents.

Sixth Annual Report of the Geological Survey of Indiana, made during the year 1874, by E. T. Cox, State Geologist, Indianapolis. Indiana, 1875. From E. T. Cox.

Instructions in the Use of Meteorological Instruments. Compiled by direction of the Meteorological Committee, by Robert H. Scott, M.A. London, 1875.

Quarterly Weather Report of the Meteorogical Office. Published by the authority of the Meteorological Committee. Part 4, October–December, 1873. London, 1875. From the Meteorological Committee.

Lessons on Hand-Railing, for Learners, by Robt. Riddell. Philadelphia, 1875. From the Author.

Also, that at their meeting, held on the 8th inst., the following preamble and resolution were adopted:

WHEREAS, We understand that measures are being taken for the establishment in Philadelphia of a Museum of Industrial Art, with facilities in connection therewith for a course of instruction in design for artisans, similar to those offered at the South Kensington Museum of London. Therefore,

Resolved, That the Board of Managers of the Franklin Institute learn of this movement with pleasure, and fully appreciating the benefit that will result to our manufacturers from it. This museum promises to furnish superior advantages for the prosecution of the work in which this Institute was a pioneer, and has labored for more than half a century, and it has our most cordial wishes for its success.

Dr. C. M. Cresson read a paper on the effect of magnetic and galvanic forces upon the strength and destruction of steel and iron structure.

Mr. Robert Briggs then presented a paper on pseudo perspective for use in mechanical illustration. The method described was isometric and gives a semblance of perspective, which for illustration of articles to be grouped, becomes more nearly correct, and is less objectionable to the eye, than when shown with different perspective planes. It had also the merit of ready production from working drawings by the engraver's draughtsman.

The Secretary presented his report on novelties in science and the mechanic arts, embracing Jas. Henderson's process of making wrought iron; Leonard Krewson's apparatus for stopping leaks in vessels; G. M. Burth's window sash fastener; Richard's fire escape; Crofutt's life protector for firemen, miners, etc.; a window blind fastener, invented by Jonathan Bell; a triple hose connection by R. Grimshaw; an improved hose coupling, by W. A. Caswell, of Providence, R. I.; a new form of link for chain cables, by C. A. Chamberlin; a conical propeller wheel, by E. C. Hubbard; an improved scale beam, by T. Tebow, and M. S. Orum's flexible mandril for bending metalic pipes.

Mr. J. W. Nystrom presented and explained a telescope for field in-

struments, the invention of himself and Mr. Young, and also an instrument to measure and determine the imperfection in object glasses.

The Secretary then projected on the screen some pictures showing the advanced state of the Centennial Buildings.

A letter was read from Sir Edward Thornton, British minister at Washington, in relation to the award of the Albert medal of the Society of Arts, London, and also a list of medals awarded from 1864 to 1874 inclusive.

On motion of Mr. Robert Briggs it was resolved that the communication of Sir Edward Thornton, relative to the Albert medal, be referred to a committee of three persons, to be appointed by the chair at his convenience, which committee are hereby instructed to acknowledge in behalf of the Institute, the communication, and are desired to report at the next meeting of the Institute what action will be necessary to present to the Society of Arts the names and testimonials of any persons entitled to the medal.

Mr. J. E. Mitchell asked to have again read the resolution of the Board of Managers in relation to an Industrial Art Museum, which was done, whereupon he offered the following, which was adopted:

WHEREAS, The establishment of a museum of science, art and manufactures receives the hearty approval of the Franklin Institute, and with a view to and in the carrying out the project, Therefore, be it

Resolved, that the chairman is hereby authorized and requested to appoint, at his leisure, a committee of five members of the Institute to confer with similar committees from other bodies, with a view to organizing an institution similar to the South Kensington Museum in London.

Dr. C. M. Cresson offered a resolution in reference to publishing an abstract of the report on steam boiler explosions, and the strength of materials, which on motion of Mr. Sellers was amended to read as follows, and then adopted:

Resolved, that the committee on publication be requested to republish, entire, the reports upon "Explosions of Steam Boilers" and "Strength of Materials" made to the Institute in 1835 and 1836.

Dr. C. M. Cresson offered the following, which was adopted:

Resolved, That the committee on Science and the Arts be requested to appoint sub-committees upon the strength of iron and steel, with directions to make such experimental trials as may be necessary to include materials such as are at present found in the market, and

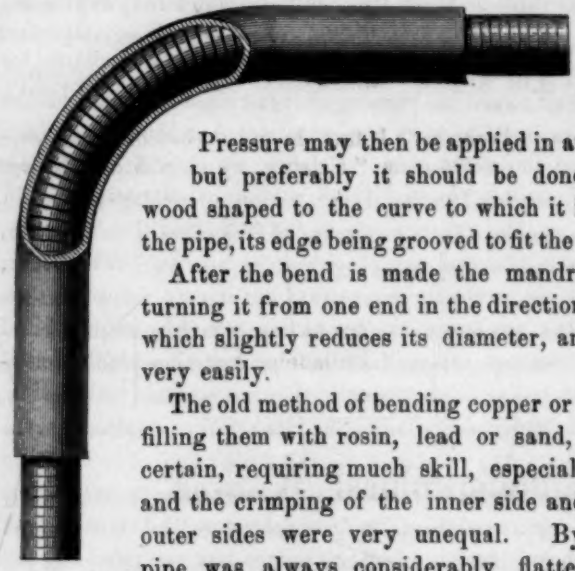
employed for the construction of boilers, bridges, and other structures of iron and steel, and that the sum of one thousand dollars be appropriated to the purpose of defraying the cost of the purchase and preparation of samples of iron and steel for the breaking machine. *Provided*, Such appropriation be deemed advisable by the Board of Managers.

On motion the meeting then adjourned.

J. B. KNIGHT, *Secretary.*

Flexible Mandril for Bending Metal Pipes.—At the stated meeting in September, this instrument was presented and explained and practically tested by bending a 2-inch copper pipe.

The mandril consists of a coiled or spiral spring, made of square steel wire, and of such size as to be inserted freely into the pipe to be bent.



Pressure may then be applied in any convenient way, but preferably it should be done with a block of wood shaped to the curve to which it is desired to bend the pipe, its edge being grooved to fit the outside of the pipe.

After the bend is made the mandril is withdrawn by turning it from one end in the direction in which it wound, which slightly reduces its diameter, and it is *screwed* out very easily.

The old method of bending copper or brass pipes by first filling them with rosin, lead or sand, is tedious and uncertain, requiring much skill, especially for large pipes and the crimping of the inner side and stretching of the outer sides were very unequal. By this method the pipe was always considerably flattened and required hammering and filing into shape.

All these objections are obviated by the use of this instrument as it leaves the pipe so near perfectly round that the eye does not detect the variation. The surface is smooth so that there is no loss of metal (and consequently of strength) by filing into shape. Besides there is probably not one-twentieth of the time required in this as in the old process, and persons with much less skill can do the work with perfect success.

A number of specimens of pipes of different metals, copper, iron, tin, brass, and of sizes from ½-inch to 2-inch were exhibited, showing the general applicability of the mandril, but notably among them was a piece of butted zinc pipe, ¾-inch diameter, and bent to a curve of 1¼ inch radius.

Editorial Correspondence.

Editor Journal Franklin Institute.

SIR: In answer to your inquiry respecting the phrase "waneedged," I can say that I never heard the expression from Philadelphia workmen, but I think your hint as to its meaning clearly points out its derivation, which is from the Anglo-Saxon *wana*, expressing deficiency or incompleteness. It means the *wanting* or imperfect edge or end of the timber. As thus derived, it might claim the slender Saxon a, and be written "wanedged." (See Chambers' Etymolog. Dict.)

Upon looking into "Webster," I find he gives the identical word as you have spelled it—notes it as "a deficiency in a board"—and marks it "Prov-English," which, I think, completes the answer.

Yours truly,

HECTOR ORR.

This reply gives the probable derivation, but does not substantiate itself. Older authorities and examples of use would be requisite.

The word is in common use with Philadelphia dealers and workers in wood.

Bibliographical Notices.

MINUTES OF PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS; *with selected and abstracted papers.* Vol. xli, Lesson 1874-75, Part III. Edited by JAMES FORREST, Assoc. Inst. C. E., Secretary.

Railway management and Dock construction, are the subjects of the papers, but the selected papers on many subjects, form most of the book. The great value of these papers, is that they are records of accomplishment, and not of proposition. Our serial engineering publications, lose most of their value as sources of information in the numerous schemes which find description in their columns, and it is very pleasant to turn from the weekly and monthly fictions of

engineering, to the real history of the art. For the serviceable use of the engineer, the Proceedings of the Institute of Civil Engineers is the most valuable of all books of reference.

MANUAL OF INTRODUCTORY CHEMICAL PRACTICE; *for the use of Students in Colleges and Normal and High Schools.* By GEORGE C. CALDWELL, S.B., Ph. D., etc., and ABRAM A. BRENEMAN, S.B., etc., in Cornell University. Ithica, N. Y., 1875. (Published by the authors.) This manual, like all other "royal roads" to learning, is evidently the work of conscientious teachers, who want to lighten the labors of students of chemistry, but who do not dread complicating exact science with a wearisome array of "nextlys." The method is in no way better than that of Fresenius, and the language at times is extremely crude and worrisome.

A conscientious study of Barker,* Regnault, or any of the recent compilations from the German will prove vastly more useful to beginners of chemistry than this manual, for it is nothing without them and a good deal of bother with them. In the glossary of "Apparatus and Manipulation," the best part of the work exists, although even this is crude and at times inexact. The statements are evidently understood by the teachers but it would be difficult for a student to comprehend by his own, unaided efforts. R.

STORMS.—*Their Nature, Classification and Law, and the means of predicting them by their embodiments, "The Clouds."* By WILLIAM BLASIUS, formerly professor of the Natural Sciences in the Lyceum of Hanover. Philadelphia. (Porter & Coates). After the health of one's friend, the general subject of universal interest to civilized mankind is the weather, but while the pursuit of knowledge in direction of the laws of health may tend to produce advantageous results, the same pursuit (under difficulties) into the laws of weather offers little prospect of improvement, and becomes at best a kind of mental chess-playing.

The study of phenomena will, however, be attractive to many minds, and the obvious and ever present one of *the weather* will find more investigation and more appreciation than many of the extensively examined subjects, and this book in its antagonism to some of the special theories, whereby other writers have tried to *simplify* to one rule, will lead towards more general knowledge of the diversity of conditions which exist. Strictly the work is neither elementary nor theoretical—perhaps it is not even logical—but it is a more succinct narration of facts and partial theories than is found elsewhere.

An exceedingly thin film of air covers the surface of our globe. Upon 200 millions of square miles is spread out a sheet of air 5 miles in thickness (the density of air being taken as upon the sur-

* "Barker's College Chemistry," New Haven, 1874.

face of the earth). The relative thickness of the atmosphere taken at this density to the extent of surface may be comprehended by saying it is that of a sheet of paper, such as the book on "Storms" is composed of, upon a sphere of 10 inches diameter, and the thickness taken at the usual supposition of 45 miles high of varying density is equivalent to 9 such sheets. This film is *boiled* by contact with the earth (generally) for 12 hours out of 24, (mainly upon a belt or zone which oscillates during the year about the tropics, but at the proper season in the temperate zones) and is condensed in the temperate and arctic zones. Tidal influences and those proceeding from the inequalities of surface of the earth also intervene.

The atmosphere is constituted of air and vapor of water; other gases or vapor, being too small in quantity to enter into consideration in influencing meteorologic phenomena.

This vapor of water would at any assumable sensible temperature and density, form that portion of a still atmosphere which its tension as steam of the same temperature would demand, but as the density of the atmosphere follows the elevation, and the sensible temperature falls away by well known laws, and the tension of steam falls off with sensible temperature much more rapidly than the rarefication of air, it follows that at some height not very elevated, an atmosphere saturated at the surface of the earth must be foggy with condensed vapor; and at some other height, yet more elevated, an atmosphere with a proportion of vapor less than saturation at the surface of the earth, would exhibit the same cloudiness.

Where clouds exist, they intercept most of the heat of the sun, and thus of themselves become a disturbing element in locating the points of ebullition from the earth's surface; and wherever evaporation is going on, the vapor of water and air form a mixture lighter than air alone, which increases the levity of the heated air.

The ebullitions are of every order—sweeping, horizontal currents, involving probably the whole depth of the atmosphere—overlaying sheets—rolls like shavings laid on the floor—spirals like the flow of water from a basin, (either on the surface of the earth, upwards, or in the upper atmosphere, downwards, transforming into sheets eventually)—and these several ebullitions *travel* over the surface of the earth in sweeps or coils of their own.

Currents of air in the form of sheets, (which are our usual winds) or in more restricted veins, acquire by impulse or by induction, high velocity, and when such velocities have been established, it must be recognized that an atom of air has as absolute momentum, as an atom of a cannon ball; but that while the cannon ball, (composed of dense atoms, compared with the medium in which it moves), from gravitation and the resistance of the medium, has a curved tragutory; the atom of air, *within the air itself*, is in equilibrium, and devoid of gravity, and its motion is a straight line. The direction of such currents, consequently, unless other influences are exerted, can be hori-

zontal only on one line of cross section, and thus every current from the line of its absolutely horizontal plane is tangential. If beyond this line, the current enters into a field or volume of still, or relatively still air of same density, it will rise from the surface of the earth, in place of following it, and at the distance of 200 miles from the normal line, attain an elevation of about 5 miles, and in the course of such elevation, a cloud will have been formed. In other words, that volume of air, in advance of the normal line of the current, which would be intercepted between the tangential plane and the earth surface, must be induced to move by some other force than the current itself, or else the current will rise above it.

This proposition of the atomic momentum of the fluid atom, having its direction or value unaffected by expansion or contraction, is the basis of the solution of the problem of the whirlwind or whirlpool, and has only been mentioned at this time, to elucidate how an extended cloud can be accounted for, without assuming counter currents or the intermingling of hot and cold strata, and to show how moderate velocity of winds may generate storms. The barometrical change produced by the supposed elevation of the undeviated current is inconsiderable.

Again, sheets or veins must manifestly have some point of maximum velocity, while with a fluid mass the stream must contract to attain such velocity, and expand in losing it. This contraction or expansion may be horizontal; sideways, on either side; or vertical, downwards or upwards. When the combination of contraction or expansion occasions a *thinning* of the sheet or vein, there is a downward shrinkage established, and the upper anhydrous air gives a clear sky; when the sheet or vein thickens, there is a piling up of the column of air, and *clouds are formed.*

Heat is not conducted between strata of air to any great extent, air or even vapor is too bad a conductor, but when two sheets, in diverse directions, one cold above, and one warm below, are sweeping by each other, the mingling is the rolling of currents between the two, and the cloud is the result of the upward roll.

The tornado is an induced upward current of the basin discharge order (following an unstable equilibrium of calm), and the same air which was breathed a few minutes earlier was that from which the hail-stones were derived. (Except that the hail-stones drop through an upward current of high velocity, they would acquire such force in falling as would produce the most disastrous effects.)

* * * * * * * * * * *

These, and similar truths, are the elements of Meteorology, and they are *not* set out in the book before us with that directness which could be desired by the student. It follows, that as a philosophical treatise, much is wanting, but as a statement of former theories and facts in ample and readable form, the work deserves many readers and high commendation.

Civil and Mechanical Engineering.

THE STEAM BOILER EXPLOSION AT THE KEYSTONE MILLS, TWENTY-FIFTH AND CALLOWHILL STREETS, PHILADELPHIA.

[It was for many years the usual practice of the JOURNAL to record the simple facts attending the explosions of steam boilers in Philadelphia, or its immediate vicinity. In accordance with this, the following communication is published. It is proposed to complete the record by similar descriptions of other explosions which have occurred within the past six or eight years.]

On Friday, May 8th, 1874, shortly after three P.M., an explosion of one of the six plain cylinder boilers, which furnished the steam-power for the Keystone Mills, took place. There were three pairs of boilers set in couples, each boiler being 30 feet long and 36 inches in diameter; the pairs having independent setting and all the appliances provided by law. Generally two pairs (or sets) were amply sufficient to give steam to drive the mills, but a few days prior to the explosion, some coal of bad quality was used, and it was found necessary to fire up the third set.

This third set had been standing idle for some time previously. In January, (1874), they had been put in condition for use in an emergency, having been then examined by the boiler inspector for an insurance company, and one of the two repaired at his suggestion.

On the afternoon of the explosion, the engineer noticed a leak in the repaired boiler, (which was the outside one of the third set), and immediately hauled the fire from this set, shut off the connections to the other two sets, and was in the act of attaching a water pipe to the blow off cock when the boiler exploded. The parting was at the third row of rivets, and the front head with two rings of the shell was projected nearly horizontally, about 150 feet, passing, in its course, through the board enclosure of a shed. The back end, with about 25 feet of the shell, was driven in the opposite direction (also horizontally) passing through a coal pile some eight feet in thickness, and stopping in a second heap of coal about 100 feet from the setting, the resistance of the coal retarding and finally arresting its flight.

The engineer, Hugh Sweeney, and a boy, Thos. Ivan Devor, were scalded and otherwise injured; both died the following day. There were narrow escapes, but no other injuries of person. The fracture followed the seam all around, partly in the line of rivet holes and partly on the line of caulking. At one place on the underside on the line of caulking, there was an old crack, with well coated surface, 17″ to 19″ long—a fracture evidently of long existence. The iron of the shell at the place of rupture had worn a little, perhaps a number of the gauge (that is, from No. 4, its original thickness, to No. 5.) The inspection had located the defect of the boiler at this seam, and there was a new patch along a part of it; the rent happening in the old sheet along the rivet holes, which joined on the new patch. As stated, 17″ to 19″ of old crack was disclosed. This weakness, together with the probable injury to the old sheet, from drifting out rivets and stretching the holes in putting in new ones, was sufficient to attribute *want of strength* as the cause of the disaster. The repairs had evidently been injudiciously made, and the boiler imperfectly examined on their supposed completion.

The experience of the writer has lead him to conclude that taking in consideration all the abuses of boilers in service, the average duration of boilers of good construction is about ten years. This boiler had been over twenty years in use, and its age should have called for close scrutiny when repairs were made.

WM. BARNET LEVAN,
Engineer.

STAND-PIPE FOR BLOOMINGTON, ILL.

By H. M. P. BIRKINBINE.

In constructing water-works for western cities, it is frequently impossible to have a reservoir, for want of the necessary elevated ground to place it upon. Many of the cities, have, therefore, been contented to adopt the direct supply plan; that is, pumping directly into the distributing mains, the plan adopted by Peter Morice, in the works built for supplying the city of London, at London Bridge, in 1582. The imperfections of such a system are apparent, the supply

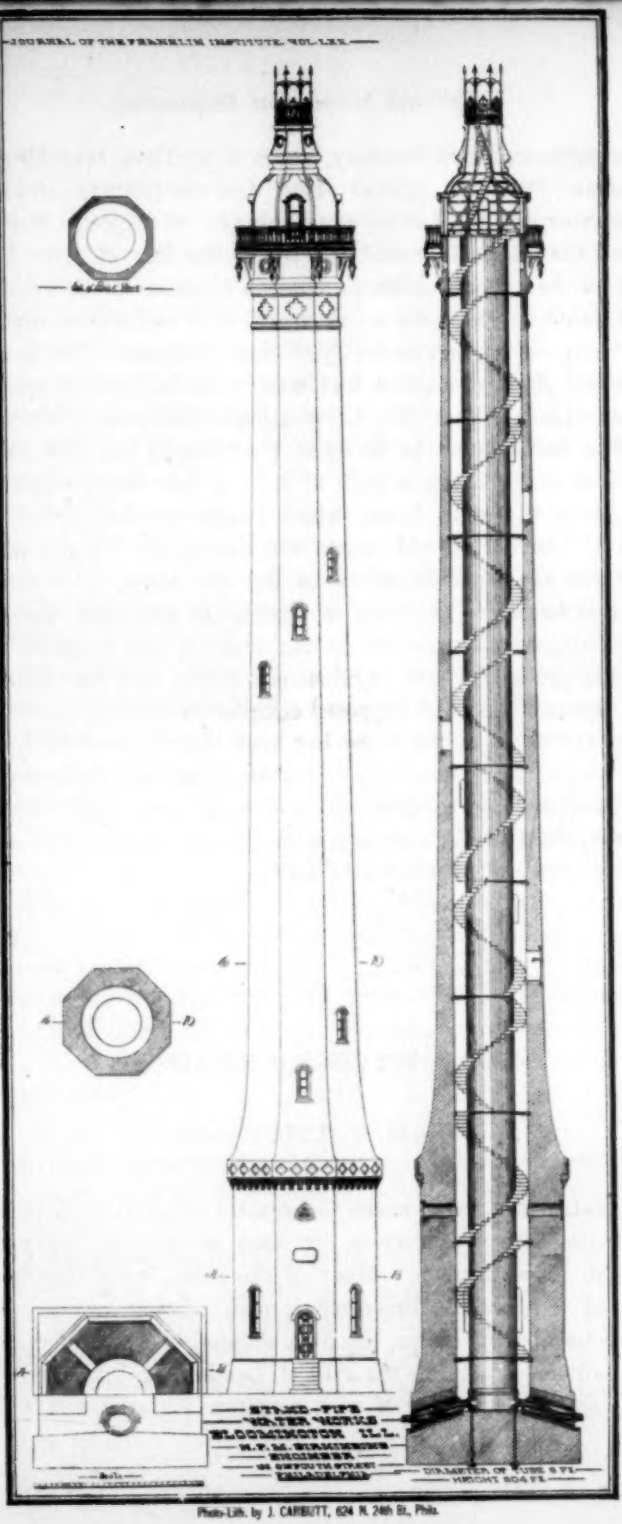


Photo-Lith. by J. CARBUTT, 624 N. 24th St., Phila.

depends entirely upon the integrity of the machinery; not a drop more can be procured than that which is pumped, and as it is pumped. The oscillations of demand must be answered directly by the operation of the pumps. The capacity of the pumping apparatus must, therefore, be equal to the maximum demand at any moment of the day or night. Expensive and complicated machinery is therefore necessary, little better than that constructed by Peter Morice, so long ago, who had two sets of *gang* pumps, four in each gang to a wheel. Very ingenious, but complicated arrangements have been devised for controlling the velocity of the modern direct supply pumps, by the pressure in the mains. The objection to this plan does not lay only in the complicated and unnecessarily large, expensive machinery, but also in the rapid wear and destruction of the apparatus. Another objection is the constant attention and watchfulness necessary, day and night, to keep up the supply of water, and the machinery in running order.

The stand-pipe is now becoming better understood and appreciated; it can scarcely be considered as a reservoir; still, it may contain a sufficient volume of water to allow for ordinary repairs, packing, stopping the pumps at night, etc.

The stand-pipe being built for Bloomington will contain 75,000 gallons. This would furnish a supply equal to a second-class steam fire engine, 400 gallons per minute, for one hour and a half, and still leave 100 feet of water in the tower, thus giving valuable protection against fire, should the pumping apparatus, for any cause, not be put into operation at the moment the fire was discovered. In the direct supply plan, not a drop of water could be procured until pumped, and sufficient pressure produced to project the water upon the fire. The stand-pipe has also a value in furnishing a place for the shocks incident to the working of pumps, opening and shutting of stops, and other like disturbing forces, to expend themselves.

The illustration represents an elevation, vertical section, and several cross-sections of the stand-pipe now being constructed for the city of Bloomington, Ill.

The pipe proper, or iron tube, is 200 feet high and 8 feet diameter, constructed of plate iron, secured to a cast iron base-plate. The plate iron varies in thickness from $\frac{5}{8}$ at the bottom to 3-16 at the top. The weight of the iron work will be 56 tons. The pipe is enclosed in brick masonry. The face bricks are white, with red brick trimmings

laid in black mortar. Fifteen hundred and thirty-nine cubic yards of brick and stone masonry will be required to enclose the pipe. An annular space of 27 inches to be left between the iron tube and the masonry, in which are suitable steps and platforms, leading to the top of the pipe. The tower is pierced with a sufficient number of windows to light the stairs. On top of the masonry is a dome 20 feet high, framed with wood, and covered with tin. Outside of this is a gallery supported upon brackets. The top of the dome has a lookout, protected by an ornamental railing, with guilded points.

This tower will present a striking appearance, and will be a landmark for a great distance around the city, and will give it a distinctive characteristic. The prospect from the summit will be grand and extensive, presenting an apportunity rarely had in that section, of looking down upon so wide an extent of country.

The contract price for building the entire structure, as represented in the illustration, is $26,700.

HOW THE METROPOLITAN RAILWAY IS WORKED.

HOWARD FLEMING.

The following description of the Metropolitan Railway (London) is extracted from the New York *Railroad Gazette* of August 28th. The success which has attended this means of communication in the large passenger traffic of a city is worthy of consideration in our important cities.

The Metropolitan Railway was commenced nearly twenty years ago, to give the Great Western Railway (having its terminus at Paddington) a city station about four miles to the east, at Farringdon Street. It has since been extended further eastward about a mile and a quarter to Bishopsgate, where it connects with the Great Eastern Railway, and from Paddington west by south to Kensington, where it connects with the Metropolitan District Railway (generally called the "District Railway,") also an underground line, which extends eastward, and of which more hereafter. These two railways form an irregular, almost complete ellipse, sixteen miles in length, of which each company possesses half.

The dimensions of tunnel are eighteen feet in height, and twenty-five feet in breadth, and the maximum distance of track from surface sixty feet. Accurate figures as to proportion of tunnel to open cut were not obtainable, but I should estimate it in the proportion of 10 to 1. The guage is 4 ft. 8½ in. The sharpest curve on main line has a radius of 627 feet and on siding 396 feet. The maximum gradient is 1 in 70. The rails are steel, 24 feet long, and weigh 86 pounds to the yard. Their average life at railway stations, where the friction is very great, is two and a half years, and at other places, eight years. They are laid in cast-iron chairs weighing 39 pounds each, which are screwed to pine cross-ties 6 ft. by 12 in. by 12 in. placed 2 ft. 8 in. apart, and their average life has been seven years. The ballast used is gravel, which does not cover the cross-ties.

The weight of locomotives is 42½ tons (of 2240 lbs.) The engines have eight wheels, a rigid wheel base of 9 feet, and a total wheel base of 19 feet. The diameter of drivers is 5 ft. 9 in.; weight on driving wheels, 32 tons. The cylinders are 17 in. by 24 in., and the boiler pressure is kept at 130 lbs. The fuel used is a medium hard, smokeless coal from South Wales, called Bwlffa coal, and the amount consumed is about 32 pounds per mile. Coke is also used. The speed maintained is 12 miles an hour, and the average mileage per engine is 130 miles per day.

The first-class cars are 40 feet long, 8 feet broad and 11 feet high, They are divided into six compartments, upholstered and decorated, each compartment containing seats for eight persons. They are mounted on two four-wheeled trucks, the diameter of wheels being 3 ft. 9 in. The car weighs, empty, 15 tons.

The second and third-class cars have the same dimensions and contain eight compartments, each seating ten persons. The only difference between the second and third class is that the former have their seats covered with leather, while the latter are simply painted boards; they weigh, empty, 14 tons.

The trains are generally made up of six cars, viz.: One first-class, two second-class, three third class. Sometimes there is an extra composite car of first and second-class compartments. Trains with six cars have a seating capacity for 448 persons, but at morning and evening, when the traffic is heavest, it is no unusual sight to see people standing up between the seats, so that the number carried generally reaches 500.

Some smaller four-wheel cars of all classes have lately been put on the line, eight of which make a train.

Between Moorgate Street, the station first after Bishopsgate, and King's Cross Station, a distance of nearly two miles, four tracks are laid, so that the cars of other railway companies having their termini adjacent to the Metropolitan Railway within that distance (and with which they connect by short branch lines) may find a central city station without impeding the running of the regular Metropolitan trains. The railway companies that have made use of this great desideratum are the Midland and Great Northern railways, whose trains enter at King's Cross; the London, Chatham & Dover, whose trains enter between Farringdon Street and Aldersgate Street Stations; the Great Western Railway, whose trains enter at Paddington, and the London & Northwestern, whose trains enter at Uxbridge road (a station on the District Railway) and run to its terminus at the Mansion House. From Moorgate Street or Mansion House a passenger can take tickets to any stations on the main lines of the railways whose trains start from those two stations.

By changing cars a passenger can get on the system of the Southeastern and Southwestern, North London and West London Railways, so that the Metropolitan railways have acted the part of a mutual friend in bringing all the large railways centering in the city together, and have been a great boon to the traveling public.

In addition to these lines, which throw an immense amount of traffic over the Metropolitan, it has extensions or feeders of its own, such as the St. John's Wood Railway, $1\frac{1}{4}$ miles in length, and the Hammersmith & City Line, which last is an entirely open road about $2\frac{1}{2}$ miles long.

Summing up, we have the Metropolitan Railway, 8 miles in length; the District Railway 8 miles in length, and the St. John's Wood Railway, $1\frac{3}{4}$ miles in length, a total of $17\frac{3}{4}$ miles, which is mainly underground railway, and the ventilation of which has always been an uppermost consideration. Air shafts had been sunk where most practicable and required, and the stations were in open cuts, so that the circulation of air might be kept up. The engineer has recently placed deflectors in the air shafts, so that the passing train drawing its smoke after it would cause it to ascend and draw down after it the needed oxygen, but notwithstanding this, there is a sulphurous taste in the mouth for a short time after traveling on it.

Between Bishopsgate and Mansion House there are 22 stations. They are about half a mile apart from each other, and rarely exceed a mile. The round journey is accomplished in 55 minutes. The line is worked on the absolute block system of signals, so that no train can enter upon a section until it is telegraphed clear from the other end. Both points and signals are so connected at junctions or switches that derailments never take place, and accidents very seldom occur, and so far as I have been able to learn, there has been no loss of life from the company's negligence.

The first train arrives at Bishopsgate at 5.47 A. M., and the first train leaves at 5.50 A. M.; the last train is dispatched at 11.47 P. M., and the last train arrives at 12.35 A. M. Between those hours 195 trains are dispatched, and 196 trains received. The greatest interval between two trains is 15 minutes, and the least 2 minutes, the average interval being 5½ minutes. The stops at stations are very brief—not more than a minute—yet in that short space of time passengers alight and get in and the train proceeds. There are signs hung over the platform telling the passengers where to wait for the class he has taken ticket for; all is so systematically arranged that there is no rush to find your class.

The following figures show the number of passengers carried during a series of years on the Metropolitan Railway—the north half of the ellipse. The largest number carried on any one day was last Whitmonday, May 17, 1875, when 260,000 passengers were transported.

Year.	Number of passengers.	Year.	Number of passengers.
1863	9,455,175	1869	36,893,791
1864	11,721,889	1870	39,160,849
1865	15,763,907	1871	42,765,427
1866	21,273,104	1872	44,392,440
1867	23,405,282	1873	43,533,973
1868	27,708,011	1874	44,118,225

During the first six months of 1875 the Metropolitan Railway carried 23,543,567 passengers, and in commenting on the report the Chairman, Sir Edward W. Watkin (now in this country as agent of the Erie bondholders,) stated that in the last year they carried, on their eight miles of railway, 46 million passengers, whereas on the London & Northwestern, with 1600 miles, they carried only 44 millions; the Great Western, with 1532 miles, carried 34 millions; the Midland, with 1114 miles, 26 millions; the Great Eastern,

with 852 miles, carried 31 millions; the London & Southwestern, with 685 miles, 20 millions; the Great Northern, with 586 miles, 14 millions; the Brighton, with 345 miles, 24½ millions; the Southeastern, with 331 miles, 23 millions; the London, Chatham & Dover, with 157 miles, 20 millions; and the North London, with 12 miles, 19 millions.

In regard to rates of passage on the Metropolitan Railway, it would be incorrect to say that it is so much per mile; for instance, the fare from Bishopsgate to Mansion House, first class, is 24 cents, gold; second class, 18 cents, gold; third class, 12 cents, gold; but the rates to Victoria Station, between the two points, are the same. From Moorgate Street to Gower Street, the fare, third class, is 8 cents gold; distance, a little over two miles; while to Sloane-square Station, more than three times the distance, the fare is the same.

For annual tickets paid for at the time the rate of fare is about 50 per cent. less, and the holder can travel with one as many times a day between the two points for which it is issued as desired. Many people therefore avail themselves of these commutation tickets.

The cost of the Metropolitan Railway has been enormous, owing to its traversing valuable city property, the figure running up to over £800,000 per mile, which is equal to to $75, gold, per inch. The working expenses are 40 per cent. of the gross earnings. At the last semi-annual meeting a dividend at the rate of 3¾ per cent. on the ordinary stock was declared, an increase of ¾ per cent. over the dividend for previous half year, and the Chairman stated that he believed the line was capable, if the trains were longer and the stations were lengthened, of a development of at least 10 to 20 per cent. in the next two or three years.

As stated above, between King's Cross Station and Moorgate Street there are four pairs of rails, and at the latter station they open out into six pairs to accommodate the trains starting from and running through that station, viz: the Metropolitan use two pairs, and run 391 trains over them daily; the London, Chatham & Dover use one pair, and run 139 trains daily over it; the Midland use one pair, and run 113 trains over it daily; the Great Northern Railway use one pair, and run 85 trains over it daily; the Great Western use those belonging to the Metropolitan, and run 121 trains over them daily, and there is one spare line for use in case of emergency, Here is a total of 849 trains handled during the day, and on holidays and special occasions the number

generally reaches 1000. In addition to these there are the trains dispatched from the junctions, and the freight trains that are passing from one railway to another, making use of the Metropolitan as the connecting line. The men who can thus manage and efficiently operate a short line with such an immense traffic without hitch or accident are truly wonderful, and Mr. Schwabe, who investigated the working of the road in 1870, may well say: "This running is unique of its kind, and it is necessary to have seen it to admit its possibility."

The District Railway with their double track work 466 trains per day between 5.30 A. M., and 12.35 midnight, at an average interval of $2\frac{1}{2}$ minutes between each train. It is in many respects similar to the Metropolitan Railway, but all of its stations being in open cuts and the ventilation being superior, it is called the "Daylight Route."

An amalgamation of the District Railway with the Metropolitan has been proposed, but the shareholders of the latter at the present time are unwilling to carry it out.

Heating Feed-Water for Steam Boilers.—The editor of the *Railroad Gazette* has (in the issue of that paper of September 11th) an article on "Heaters for Locomotives," with a full demonstration that, supposing the temperature of feed-water be 40° Fah., the percentage of economy due to an increase of temperature of each 10° (over the 40°) derived from the heater is 0·85 of 1 per cent.

If the heater could raise the temperature of feed-water from 40° to 220°, the total gain would be only 15·25 per cent.

10 to 15 per cent. of the fuel, and work in handling it, and especially 10 to 15 per cent. increase of power may be too great a gain to be overlooked; but when the cost and maintenance of the heaters, the liability to get out of order, the impairment of the exhaust, etc., is considered, "it is evident that a feed-water heater, instead of being economical, may be the reverse." These deductions apply to all boilers and engines, as well as to locomotives although some of the conditions of application of heaters to stationary boilers are much more favorable for the use of heaters. It must be noticed, however, that under no circumstances can the percentage of advantage be greater numerically than is stated above.

GAS WORKS ENGINEERING.

By Robert Briggs, Civil Engineer.

The subjoined plans and specifications are examples of the more recent practice for telescopic holders and tanks constructed in the plainest and most economical manner compatible with good workmanship. The work was performed under contracts between the Citizen's Gas Light Company, of Buffalo, and the Southwark Foundry, of this city, for the holder, and between the same Gas Company and a building contractor of Buffalo for the tank. In the following number of the Journal will appear a description of an accident which ensued, and of the steps taken to repair the injury, with a discussion and report upon the subject.

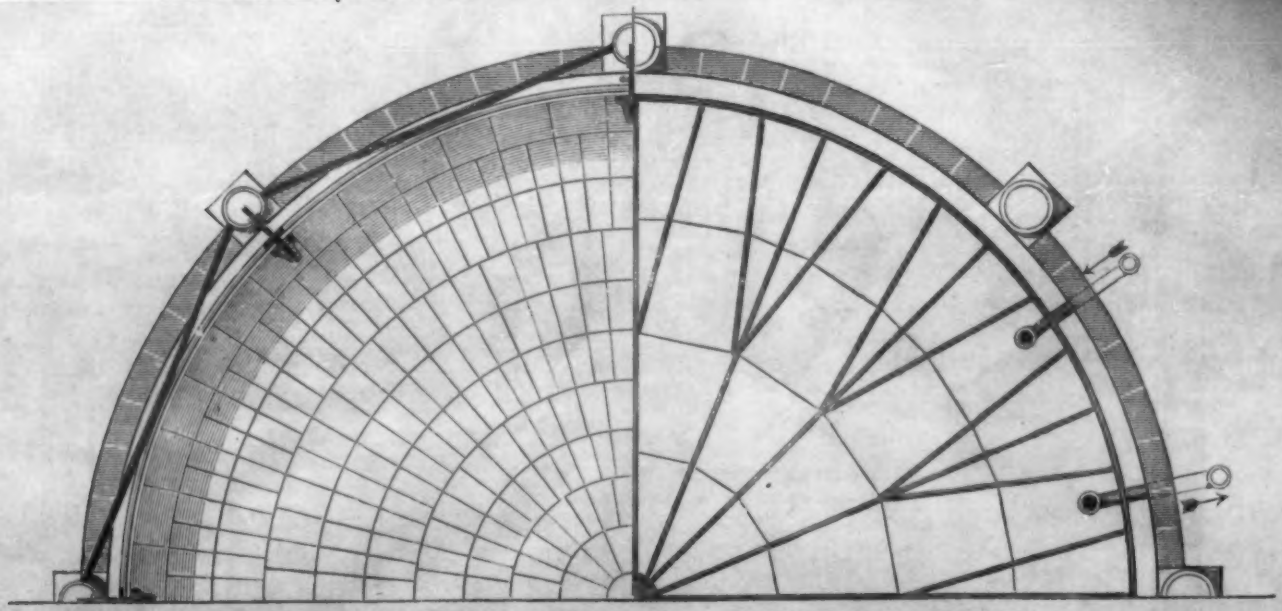
SPECIFICATION FOR A TELESCOPIC GAS HOLDER.

Citizens' Gas Light Co., Buffalo, N. Y.

Inner Section, .	Diameter,	88 feet 6 inches.
	Height,	22 " 0 "
Outer Section, . .	Diameter,	90 feet 0 inches.
	Height,	22 " 0 "
Cup, ...	Depth,	1 foot 3 inches.
	Width,	6 "

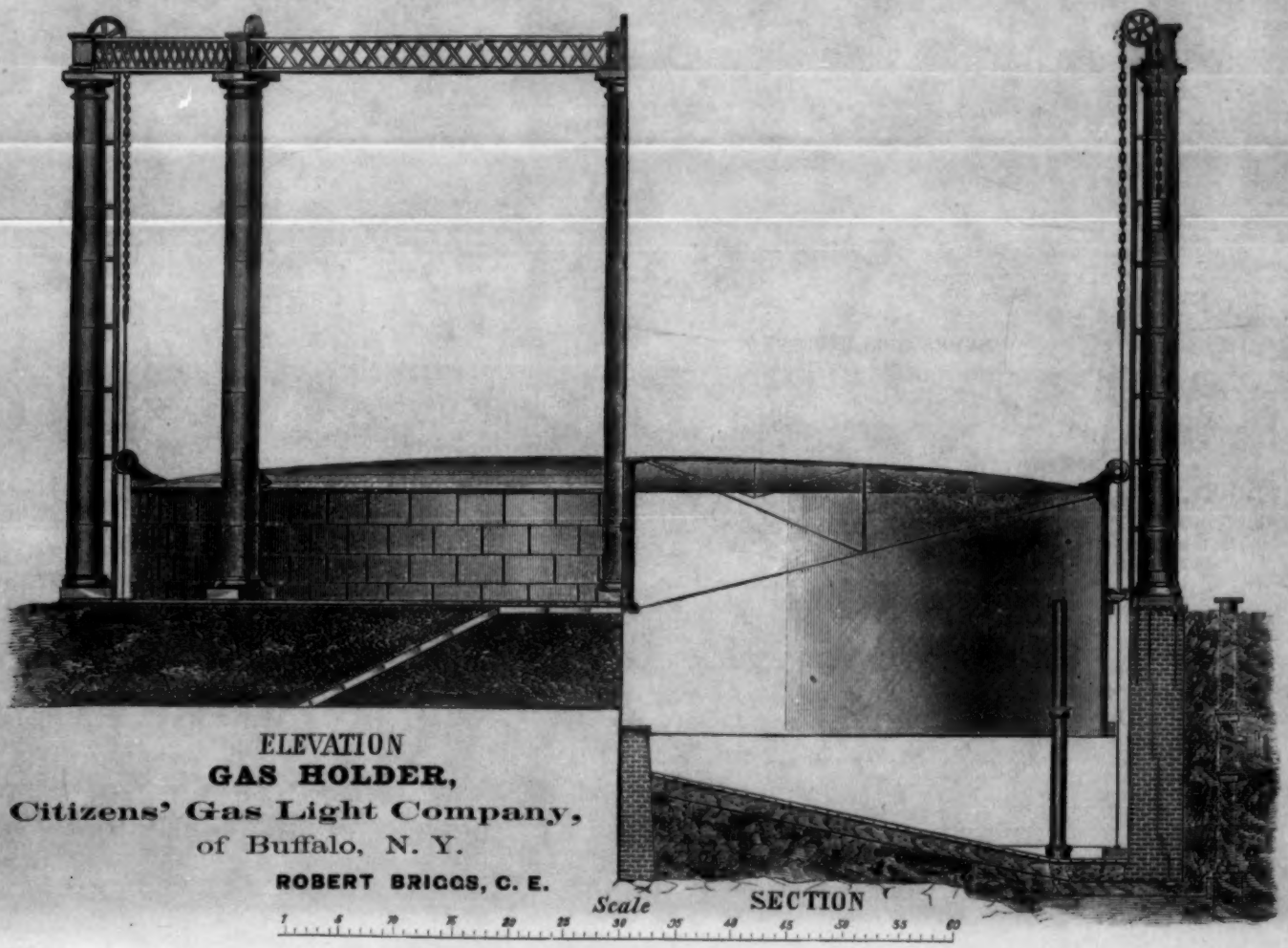
Working contents of Holder, 265,722 cubic feet.

This Holder will have a weight of $3\frac{5}{10}$ inches water pressure, when the Inner Section is down, which will be constant within $\frac{1}{10}$ inch, whilst the Inner Section lifts. The lifting of the Cup will increase the pressure $\frac{3}{10}$ inch, making $3\frac{8}{10}$ inches, and the Outer Section will be counter-balanced to $\frac{8}{10}$ inch pressure, making the maximum pressure $4\frac{6}{10}$ inches. The levity of the gas will very nearly balance the gain of weight of the sides as they lift from the water.



TOP VIEW of SHEETS

TOP VIEW of ROOF FRAME



ELEVATION

GAS HOLDER,

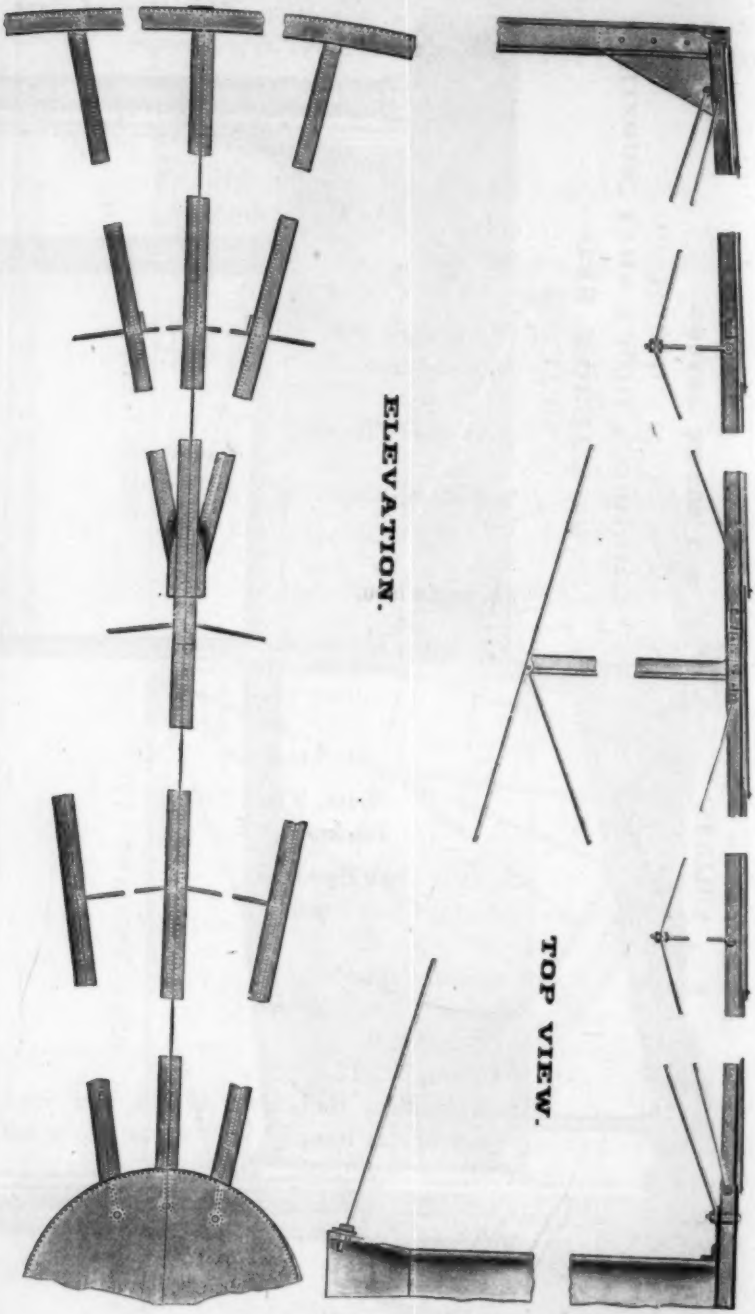
Citizens' Gas Light Company,

of Buffalo, N. Y.

ROBERT BRIGGS, C. E.

SECTION

Scale



Framing of Crown of Gas Holder.

Crown to have the curvature of a portion of a sphere of three hundred and fifty feet radius, equal to 2 feet $9\frac{5}{8}$ inches rise.

FRAMING OF CROWN.

One Column King Post	Diameter, 1 foot 8 inches. Length, 14 feet 0 " Thick. of Sheets $\frac{5}{16}$ "
16 Queen Posts, tee iron, .	$3\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{7}{16}''$
16 Main Rafters, " . .	$4'' \times 4'' \times \frac{7}{16}''$
32 Secondary Rafters, angle iron,	$3'' \times 3'' \times \frac{3}{8}''$
16 Main Tie Rods, round iron, .	$1\frac{1}{4}''$ diameter.
16 Secondary " " .	1 " "
32 Struts to Independent Trusses, round iron, ...	$\frac{7}{8}''$ "
32 Struts to Main Rafters, round iron,	$\frac{7}{8}''$ "
64 Tie Rods, " "	$\frac{3}{4}''$ "
80 Purlins, flat iron, ...	$2\frac{1}{2}'' \times \frac{3}{8}''$
Curb of Crown, angle iron, .	$4'' \times 4'' \times \frac{7}{16}''$

CROWN.

Centre Sheets, .	Diameter, 4 feet 0 inches. " 3 " 6 " Thicknesses, $\frac{1}{2}''$ $\frac{3}{8}''$
Curb Sheets, .	Width, 3 feet 3 inches. Thickness,* No. 9.

Inner row of Sheets next to Curb Sheets—
Length of Sheets, 4 feet 2 inches.
Thickness " No. 9.
Outer row of Sheets next to Centre—
Length of Sheets, 4 feet 2 inches.
Thickness " No. 9.
Remaining Sheets of Crown, No. 12.

16 Legs of Inner Section, Bulb iron, 45 lbs. per yard, and to have a backing plate of flat iron, $5'' \times \frac{1}{4}''$ on outside of section, countersunk riveted.

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* Refers to Birmingham Wire Gauge.

SHELL OF INNER SECTION.

(Upper) Curb Sheets, { Width, 2 feet 0 inches. Thickness, No. 9.

(Lower) Cup Sheets, { Width, 3 feet 0 inches. Thickness, No. 9.

Intermediate Sheets, " No. 14.

CUPS, (both Inner and Outer Sections.)

Bottom, flanged channel iron, No. 58, $6'' \times 2\frac{1}{16}'' = 11$ lbs. per foot.

Sides, . . . { Width, 1 feet 3 inches. Thickness, No. 9.

Edge, bead iron, $2'' \times \frac{7}{8}''$.

16 Legs of Outer Section, flat iron, $2'' \times 1''$, and to have backing plate on outside of section, of flat iron, $5'' \times \frac{1}{4}''$.

SHELL OF OUTER SECTION.

(Upper) Cup Sheets, { Width, 3 feet 0 inches. Thickness, No. 9.

(Lower) Curb Sheets, { Width, 3 feet 0 inches. Thickness, No. 9.

Intermediate Sheets, " No. 14.

Curb of Lower Section, angle iron, $4'' \times 4'' \times \frac{7}{16}''$.

All splices, gussets, thickening plates, where brackets are attached, &c., to be of suitable dimensions. Hand rail, of proper height, on top of Inner Section, and manholes on crown of same.

8 adjustable Carriages, base plates and guide wheels on top of Inner Section.

8 adjustable Carriages, with guide wheels and rollers for cup of Outer Section.

8 adjustable Carriages, with rollers for cup of Outer Section.

16 " " with rollers on curb of " "

16 " " with rollers on cup of Inner "

Two coats of metallic paint to be applied, one before shipment and one after erection; the latter coat on inside and outside of Holder.

Holder Frame.

8 Iron Columns, placed at equal distances around circle formed by the Tank, which shall be 91 feet 6 inches diameter.

Each Column to be constructed as follows:

The Base, Capital, and Entablature, to be of cast iron, of 1 inch average thickness.

The Base to be 2 feet 3½ inches high, and 4 feet 8 inches × 4 feet 8 inches at foot, and to be provided with 4 holes, through which the foundation bolts will pass.

The Capital to be 2 feet 3 inches deep, and 4 feet 4 inches × 4 feet 4 inches at top.

The Entablature to be 3 feet 4 inches high, and securely bolted to capitals.

The Shaft at base to be 3 feet 4 inches diameter, and at top 2 feet 8 inches diameter, and 44 feet 0 inches high, and to consist of 8 sections of wrought iron. General thickness of iron in sections to be $\frac{5}{16}$ inches.

The Joints of the bases, capitals, and of each section of shafts, to planed, or turned off true and smooth, and the several parts secured together by $\frac{5}{8}$ inch bolts not less than 4 inches apart, or by $\frac{5}{8}$ inch rivets, countersunk flush on outside, 3½ inches apart. [The vertical and horizontal joints in wrought iron sections to be made by plates $6'' \times \frac{5}{16}''$, with $\frac{5}{8}$ inch rivets, countersunk on outside, not less than 3½ inches apart.]

Upon each column will be placed 7 Brackets to carry the guide rails, 5 feet 6 inches apart, bolted to the shaft of the column.

The Guide Rails of Railroad Iron, 20 pounds per foot, to be placed on each column, bolted to bases, capitals, and brackets, and to extend the entire height of column.

8 Wrought Iron Lattice Girders, 3 feet 0 inches high, connecting columns together at top, composed of two pieces of angle iron, 3 inches × 3 inches × $\frac{5}{8}$ inch at top and bottom, with flat iron, 3 inches × ¼ inches, crossed and riveted to angle iron, and at intersections.

Girders firmly bolted to capitals, and connected to entablature.

8 Chain Wheels, 3 feet 0 inches diameter, attached to entablature in such manner that the chain will pass through the centre of col-

umn, and in a perpendicular line with edge of cup of outer section of holder.

Counterbalance Weight, of 1200 pounds in each column, of convenient shape to move clear in the column.

8 Counterbalance Chains, $\frac{3}{4}$ inches diameter, connected by shackles to rod of weights and to crosshead.

8 Crossheads, with two rods, connecting chain to cup of outer section of holder, so constructed that the guide wheel of inner section will work free of chain.

A WROUGHT IRON LADDER on one of the columns, extending from top to bottom, of proper proportions.

16 Guide Plates, cast in pieces convenient lengths, and extending from top to bottom of Tank.

32 FOUNDATION BOLTS, 2 inches diameter, and 10 feet 0 inches long, to be built in Tank wall, and secured by cast iron washers, 12 inches $\times$ 12 inches $\times$ $1\frac{1}{2}$ inches at centre, and $\frac{3}{4}$ inches at edge.

CAST IRON PIPE, as per drawing, for 12 inch Inlet and 16 inch Outlet to Tank of Holder, with two drip boxes, 16 and 24 inches diameter, $\times$ 3 feet 0 inches, and $\times$ 3 feet 6 inches deep, with hand pump for same.

Two coats of metallic paint to be applied on all exposed surfaces of the Holder Frame, one before shipment and the other after erection; the inside of wrought iron columns to be painted.

The whole of the work specified to be delivered at Buffalo, and erected on the grounds of the Citizens' Gas Light Co., on the lot at the junction of Court and Georgia Streets, on or before the first day of December, 1874.

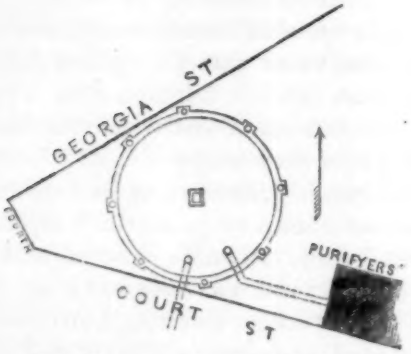
It is stipulated that the Tank shall be kept dry by the Gas Company, and that lumber for scaffolding shall be provided by them. The erection of and removal of which will be done by the builder, and the material shall be used without unnecessary waste, and, on completion of the Holder, be carefully piled upon the adjacent ground.

All carpenter work, masonry, excavation, and the placing of inlet and outlet pipes, and setting of foundation bolts and washers, and of tank guides in wall of tank, shall be done by the Gas Company.

All material to be of the best quality, and the work done in first-class manner, subject to the inspection, and to be completed to the satisfaction of the Engineer of the Gas Company.

SPECIFICATION OF TANK FOR GAS HOLDER.

CITIZENS' GAS LIGHT CO., Buffalo, N. Y.



PLAN OF LOCATION OF HOLDER

INSIDE DIMENSIONS, { 91 feet 6 inches diameter.
22 " 8 " depth.

The level of top surface of curb will be 0 feet 8 inches above the general level of the ground around the tank, or 5 feet 6 inches above general level of the side-walks on Court and Georgia Streets.

The side walls and piers for the columns will be constructed in brick; the bottom and wall footings in brick or concrete (or brick with concrete.) There will be stone anchor blocks, stone coping around wall, and stone cap for centre pier, in manner and of dimensions hereinafter specified :

EXCAVATIONS.

The Excavation must be 97 feet 6 inches in diameter, with 8 recesses 5 feet 0 inches in length by 1 foot 10 inches in width (measured outside of diameter of tank excavation) for the piers of column foundation.

The excavation must be 24 feet 4 inches in depth, measured from upper surface of curb coping, or as much deeper as necessary to obtain good foundation, and be brought to a uniform level. Except that, in case the excavation is in rock, indurated clay or earth, or in

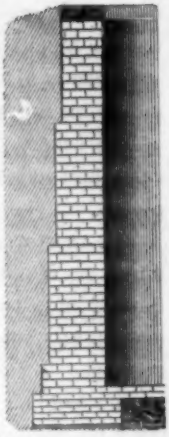
compact gravel, the recesses for column piers may then be made not deeper than one foot below column foundation bolts. And except where it is desirable to economize in removal of earth or stone from bottom of tank, when a cone with an inclined surface not more than one vertical in three horizontal may be left. The base of this cone must be at least 6 feet from inside face of the wall.

There is also to be excavated a recess and trench for the inlet and outlet pipes and drips, which are to be placed in position, as shown in accompanying plan, which excavation shall be of proper dimensions and depth, to allow the Gas Company to make joints. After the joints are made, the recess and trench must be filled and rammed with earth (or concrete, if necessary), as solid as the original ground. The sides of the excavation must be carefully shored to prevent caving; and in case of a slip, the entire mass of broken earth must be removed, and a new fill puddled and rammed in the back of wall.

If the bottom of the tank proves springy, there must be constructed a system of blind drains leading to a brick well, 3 feet 0 inches in diameter, and 1 foot 0 inches in depth below bottom of drains, which well shall be placed close to the walls of tank where most convenient to pump from. This well must have a cast iron plate (with poppet valve 8 inches in diameter) built into it one foot from top. The blind drains must be laid so that their covering bricks or stones will be under the concrete bed. There must be no attempt to keep the water out of the tank by the masonry of the bottom, but the springs must be allowed to discharge into the well, and through the valve into the tank; from which the water must be pumped by the contractor for the tank until the completion of the holder. In all cases, the bottom of the tank shall be made of a layer of concrete 15 inches in depth, with two courses of brick on flat on top of same.

The inlet and outlet pipes and drips must be placed by the contractor for tank. The joints will be made by the Gas Company at the proper time.

The tank guides and anchors will be built into the walls. The best method of holding the tank guides in position is to nail them by 12^{d} nails to six inch square wooden posts, placed inside the circle of the walls; which posts can be set plumb in the brickwork of wall footing at their bottom ends, and stayed to bank at their top ends. The posts can be removed after the walls are up, and the nails broken off.



The wall of Tank will be 4 bricks in thickness at the bottom or place of starting, which will be 20 inches below bottom of tank. [The footing will project ½ brick at back of wall, and 1½ bricks in front of wall.] The footing must be started at the level of bottom of blind drains, or of concrete, when there are no drains. The wall will contain 4 bricks for 2 feet 1 inches height. Then falling off to 3½ bricks in thickness for 7 feet 0 inches of height. Then falling off to...bricks in thickness for...feet...inches of height. Then falling off to...bricks in thickness for...feet...inches of height. Then falling off to 2½ bricks in thickness to curb.

The 8 column foundations will be in brick work, starting from bottom of excavation, as before described, and carried up plumb 5 feet 0 inches in length (along wall of tank), 4 feet 10 inches in width (measured from inside face of wall of tank), built up solid with and bonded into wall of tank. The foundation washers and bolts are to be set in position shown on drawing for these column foundations, as the work progresses.

Great care must be taken in setting out the circle of the tank, in the location of tank guides, and of the column foundations.

If the level of the ground around any part of the tank is such as to demand a bank of over two feet, and not over 5 feet) in height, the brick work must (against such higher bank) be increased in thickness a half brick by the omission of the uppermost reducing offset.

There will be laid in the course of mortar joint on the flat each ten courses of bricks; 3 or 4 strips of hoop iron 1¼ inches No. 20. 8 to 10 feet length, the ends overlapping about two feet, to make the bond of the wall. Every offset course and fifth course of bricks must be a heading course, and the heading courses must bond together across the wall.

The curb and column stone must be of N. R. flagging not less than 5 inches thick, or of Medina stone 8 inches thick. The curb must be flush with the inside of wall, and overhang the back 2 inches. The joints and edges of the curb must be carefully cut.

There are to be 16 anchor blocks of stone true and level on top, 24 inches long, 10 inches wide, 10 inches thick, placed at the foot of

each tank guide, 12 inches on one side of centre of same. These anchor blocks must be all at one level.

There is also to be provided a cap stone 3 feet 6 inches × 3 feet 6 inches on top by 10 inches thick for the centre pier.

The centre pier is to be built up to 13 feet 0 inches below top of curb, and left unfinished and uncapped until after the Holder is completed.

The mortar to be used for bricklaying, concrete, or cementing, must be made of one part of new hydraulic cement, of approved quality, and two parts of sharp sand, and must be used as fast as made; any set mortar must be rejected, and not tempered into new mortar.

The bricks used must all be hard burned and sound, and no bats must be received at the Tank. They must be properly wet down previous to laying, so as not to dry the water out of the mortar before it sets. Each brick must be laid and bedded in mortar, separately, and the end and side joint struck flush, before laying the next brick. (If the contractor will take the responsibility, he may lay the brick work by bedding each course in a cement mortar bed, and grout the side and end joints.) The brick work to be such as is usual in cistern or water tank work, of the best construction. Any brick work not meeting the approval of the engineer (or inspector for brick work, authorized by the Gas Company), must be at once removed, and reconstructed without cost to the Gas Company.

The Gas Company will hold the contractor responsible for the cost of reconstruction, and for damages which may follow, if the workmanship and material does not conform to this specification, whether noticed by the inspector or not; but will assume full responsibility for the tightness of the Tank, if the work is as specified.

Any surplus material from excavation must be deposited and leveled to the satisfaction of the engineer, within 60 feet of the Tank, and what is not thus used removed by the contractor.

Behind the walls of the tank there shall be filled in, rammed and puddled, suitable material to form a water-tight solid bank, and where the walls rise above the original surface, all loam or soil earth shall be removed for a space of 8 feet in width, and suitable puddle bank material substituted.

The bank shall be graded up to level of top of curb-stones, 6 feet in width, with a slope of two horizontal to one vertical to surface of

ground around. If the core of this bank be formed of clay, or material liable to be disturbed by frost, then there shall be eighteen inches of clean gravel spread on outside.

There shall be a cement plaster coat struck on inside of walls, before construction of Holder, and upon the surface of bottom, after construction of Holder.

If the Tank or excavation can be kept free from water, by the use of a hand pump, with two workmen employed in pumping, such pump and workmen shall be provided by and at the cost of the contractor. But should the quantity of water prove beyond the control of two men and a hand pump, the Gas Company shall provide and operate a steam pump of adequate size, with its boiler, and suction and discharge piping, without cost to the contractor.

It is stipulated, if the nature of the ground shall make it necessary to modify or change any of the requirements of this specification such as sheet piling or coffer dam work in the excavation, building in trench to retain the banks, flooring under walls or bottom for sandy foundation, or piling for foundation, then such modification as may be authorized by the Company's engineer shall be made to meet the contingencies, and the extra cost of such changes shall be equitably paid by the Company.

It is presumed that the excavation will be in earth of some kind solely; but if rock is encountered, the quantity of rock to be removed from the inside of the tank shall be determined by the engineer of the Gas Company, and an extra price of...per cubic yard will be allowed the contractor for all rock removed. The stone after removal to belong to the Gas Company, if they desire to have it, but otherwise to be taken away by the contractor.

Additional Specifications of Gas Holder Tank.

There are to be built on the line of the lot on Court Street and on Georgia Street, two retaining walls in stone masonry, each about 32 feet in length (exclusive of wings at either end, which may be needed to hold the bank.)

These retaining walls, above level of sidewalk, are to be on the line of the lot and are to be carried up to the level of top of curb, (allowing a proper wash.)

Below level of sidewalk, these retaining walls are to have a footing upon the natural ground (under soil) and at least 3 feet under side-

walk level, which footing shall spread two inches in every foot of depth.

These retaining walls shall be built up solid against the brick walls of the tank, and the coping must be extended to cover both the tank wall and the retaining wall.

At the ends of the retaining walls there will be required wing walls from 18 inches to 2 feet in thickness with foundations at least 3 feet below sidewalk level, suitably coped.

All this stone masonry is to be rubble, mostly in two or three men stone and laid in gravel mortar. The retaining walls grouted in each foot of bedding. The coping to be same as specified for tank walls.

If any stone is taken from the tank, the contractor may use the same as far as it goes if it conforms to this specification.

The excavation for these walls will be made to such depth as may be directed by Engineer of Gas Company, and the materials removed or disposed of as provided herein for material taken from tank pit.

The retaining wall and wall of shed on east side of lot must be shored with spur shores or needles, and protected during the excavation and construction of the tank.

The water will be drawn from tank of Holder nearest the excavation as a safe-guard.

The contracts were as usual in such cases, and stipulated the terms of payment (that for the tank included the time of completion). As a part of the engineering of gas works it is not necessary to reproduce the forms of contract here.

(To be continued.)

Railway Safety and Practice.—At the recent meeting of the British Association, at Bristol, Mr. F. J. Bramwell delivered a well considered address on safety appliances to railways. Probably no person in England was better prepared to discuss the subject. But those observations which refer to tires are not at all applicable to American car wheels; Bessemer boiler plates may be interesting, but at this time are not to be considered in our practice; the block system appertains so little to our long line *time* running, as not to be a subject for our consideration. The locking of points has little practical value to us, and our heavy weight trains, with liability to line obstructions, lead to conclusions as to the value of brakes entirely at variance with the English estimation. With an evident completeness, from the English point of view, it is a curious comment that Mr. Bramwell's remarks have but little relevance to American railroads.

EXPERIMENTS MADE AT THE MARE ISLAND NAVY-YARD, CALIFORNIA, WITH DIFFERENT SCREWS APPLIED TO THE UNITED STATES STEAM LAUNCH NO. 4, TO ASCERTAIN THEIR RELATIVE PROPELLING EFFICIENCY.

By Chief Engineer B. F. Isherwood, U. S. N.

[Continued from Vol. lxx, page 177.]

Results with screw B.—This screw was two-bladed, and had the next greatest surface to screw C. Their surfaces compared as $5\frac{1}{2}$ to $8\frac{5}{8}$, and were of exactly the same kind.

With the blades of screw B held stationary in the vertical position, immediately behind the stern-post of the vessel, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour was 828 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 197 pounds. Consequently, the screw, with its blades in the vertical position, increased the vessel's resistance $\left(\frac{197 \times 100}{631} =\right)$ 31·22 per centum; and decreased its speed ($\sqrt{631} : \sqrt{828} :: 7 : 8{\cdot}0186$; and $8{\cdot}0186 - 7{\cdot} =$) 1·0186 geographical miles per hour, or $\left(\frac{1{\cdot}0186 \times 100}{8{\cdot}0186} =\right)$ 12·73 per centum.

With the blades of screw B held stationary in the horizontal position, square across the vessel, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour, was 976 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 345 pounds. Consequently, the screw, with its blades in the horizontal position, increased the vessel's resistance $\left(\frac{345 \times 100}{631} =\right)$ 54·68 per centum; and decreased its speed ($\sqrt{631} : \sqrt{976} :: 7 : 8{\cdot}7058$; and $8{\cdot}7058 - 7{\cdot} =$) 1·7058 geographical miles per hour, or $\left(\frac{1{\cdot}7058 \times 100}{8{\cdot}7058} =\right)$ 19·59 per centum.

From the above it appears that screw B, when its blades were held in the horizontal position, square across the vessel, had $\left(\frac{345}{197}=\right)$ 1·751 times the resistance it had when its blades were held in the vertical position, immediately behind the vessel's stern-post.

When screw B was allowed to revolve freely by the pressure of the water on the forward face of its blades, it made 921 revolutions per geographical mile, which number was not affected by the speed of the vessel, but remained constant for all speeds from $5\frac{1}{2}$ to 7 geographical miles per hour. The axial speed of the screw was consequently $\left(\frac{6086-5{\cdot}136\times 921\times 100}{6086}=\right)$ 22·28 per centum less than the speed of the vessel, and when the latter was 7 geographical miles per hour the screw was dragged bodily through the water at the speed of 1·559 geographical miles per hour. The revolutions of this screw were uniform, and there was no appearance of hesitation when the blades came into the vertical position behind the stern-post of the vessel.

With the vessel at the speed of 7 geographical miles per hour, and screw B revolving freely, the aggregate resistance of vessel and screw was 736 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 105 pounds. Consequently, the screw, when revolving freely, increased the vessel's resistance $\left(\frac{105\times 100}{631}=\right)$ 16·64 per centum; and decreased its speed ($\sqrt{631}:\sqrt{736}::7:7{\cdot}5600$; and $7{\cdot}5600-7{\cdot}=$) 0·5600 geographical mile per hour, or $\left(\frac{0{\cdot}5600\times 100}{7{\cdot}5600}=\right)$ 7·41 per centum.

From the foregoing it appears that the resistance due to screw B, when revolving freely, is 14·58 per centum of the resistance of the vessel, *per se*, less than when it is held stationary with its blades behind the stern-post in the vertical position; and 38·04 per centum less than when it is held stationary with its blades in the horizontal position, square across the vessel.

Results with screw A.—This screw was two-bladed, and had exactly double the surface of screw C, the surfaces of both being of exactly the same kind.

With the blades of screw A, held stationary in the vertical position immediately behind the stern-post of the vessel, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour, was 981 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 350 pounds. Consequently, the screw, with its blades in the vertical position, increased the vessel's resistance $\left(\frac{350 \times 100}{631} = \right)$ 55·47 per centum; and decreased its speed ($\sqrt{631} : \sqrt{981} :: 7 : 8{\cdot}7281$; and $8{\cdot}7281 - 7 =$) 1·7281 geographical miles per hour, or $\left(\frac{1{\cdot}7281 \times 100}{8{\cdot}7681} = \right)$ 19·80 per centum.

With the blades of screw A held stationary in the horizontal position, square across the vessel, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour was 1071 pounds; deducting from which the 631 pounds due to the resistance of the vessel there remain for the resistance of the screw, *per se*, 440 pounds. Consequently, the screw, with its blades in the horizontal position, increased the vessel's resistance $\left(\frac{440 \times 100}{631} = \right)$ 69·73 per centum; and decreased its speed ($\sqrt{631} : \sqrt{1071} :: 7 : 9{\cdot}1196$; and $9{\cdot}1196 - 7 =$) 2·1196 geographical miles per hour, or $\left(\frac{2{\cdot}1196 \times 100}{9{\cdot}1196} = \right)$ 23·24 per centum.

From the above it appears that screw A, when its blades were held in the horizontal position, square across the vessel, had $\left(\frac{440}{350} = \right)$ 1·257 times the resistance it had when its blades were held in the vertical position, immediately behind the vessel's stern post.

When screw A was allowed to revolve freely by the pressure of the water on the forward face of its blades, it made 921 revolutions per geographical mile, which number was not affected by the speed of the vessel, but remained constant for all speeds from $5\frac{1}{2}$ to 7 geographical miles per hour. The axial speed of the screw was consequently $\left(\frac{6086 - 5{\cdot}136 \times 921 \times 100}{6086} = \right)$ 22·28 per centum less than the speed of the vessel, and when the latter was 7 geographical miles per

hour, the screw was dragged bodily through the water at the speed of 1·559 geographical miles per hour. The revolutions of this screw were uniform, and there was no appearance of hesitation when the blades came into the vertical position.

With the vessel at the speed of 7 geographical miles per hour, and screw A revolving freely, the aggregate resistance of vessel and screw was 765 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw *per se*, 134 pounds. Consequently, the screw, when revolving freely, increased the vessel's resistance $\left(\frac{134\times 100}{631}=\right)$ 21·24 per centum; and decreased its speed ($\sqrt{631} : \sqrt{765} :: 7 : 7{\cdot}7075$; and $7{\cdot}7075 - 7 =$) 0·7075 geographical mile per hour, or $\left(\frac{0{\cdot}7075\times 100}{7{\cdot}075}=\right)$ 9·18 per centum.

From the foregoing it appears that the resistance due to screw A, when revolving freely, is 34·23 per centum of the resistance of the vessel, *per se*, less than when it is held stationary with its blades behind the stern-post in the vertical position; and 48·49 per centum less than when it is held stationary with its blades in the horizontal position, square across the vessel,

Results with screw E.—This screw was four-bladed, with the blades equispaced around the axis. Each blade was exactly the same as one of the blades of screw C, so that screw E had the same kind of surface as screw C, and just double the quantity.

With screw E held stationary in such position that two of its blades were vertical and immediately behind the stern-post of the vessel, the other two being horizontal and square across the vessel, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour, was 941 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, 310 pounds. Consequently, the screw, with its blades in the above position, increased the vessel's resistance $\left(\frac{310\times 100}{631}=\right)$ 49·13 per centum; and decreased its speed ($\sqrt{631} - \sqrt{941} :: 7 : 8{\cdot}5483$; and $8{\cdot}5483 - 7 =$) 1·5483 geographical miles per hour, or $\left(\frac{1{\cdot}5483\times 100}{8{\cdot}5483}=\right)$ 18·11 per centum.

With screw E held stationary in such position that all its blades stand at the angle of 45 degrees with the horizon, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour, was 968 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 337 pounds. Consequently, the screw, with its blades in the above position, increased the vessel's resistance $\left(\frac{134 \times 100}{631} =\right)$ 22·24 per centum; and decreased its speed ($\sqrt{631} : \sqrt{968} :: 7 : 8{\cdot}6696$; and $8{\cdot}6696 - 7 =$) 1·6696 geographical miles per hour, or $\left(\frac{1{\cdot}6696 \times 100}{8{\cdot}6696} =\right)$ 19·26 per centum.

From the above it appears that screw E, when its blades were held at the angle of 45 degrees with the horizon, had $\left(\frac{337}{310} =\right)$ 1·087 times the resistance it had when two of its blades were held in the vertical position immediately behind the vessel's stern-post and the remaining two blades in the horizontal position square across the vessel.

When screw E was allowed to revolve freely by the pressure of the water on the forward face of its blades, it made 921 revolutions per geographical mile, which number was not affected by the speed of the vessel, but remained constant for all speeds from $5\frac{1}{2}$ to 7 geographical miles per hour. The axial speed of the screw was consequently $\left(\frac{6086 - \overline{5{\cdot}136 \times 921} \times 100}{6086} =\right)$ 22·28 per centum less than the speed of the vessel; and when the latter was 7 geographical miles per hour, the screw was dragged bodily through the water at the speed of 1·559 geographical miles per hour. The revolutions of this screw were uniform, and there was no appearance of hesitation when the blades came into the vertical position behind the stern-post of the vessel.

With the vessel at the speed of 7 geographical miles per hour, and screw E revolving freely, the aggregate resistance of vessel and screw was 765 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 134 pounds. Consequently, the screw, when revolving freely, increased the vessel's resistance $\left(\frac{134 \times 100}{631} =\right)$ 21·24 per centum

and decreased its speed ($\sqrt{631} : \sqrt{765} :: 7 : 7{\cdot}7075$; and $7{\cdot}7075 - 7 =$) 0 7075 geographical mile per hour, or $\left(\frac{0{\cdot}7075 \times 100}{7{\cdot}7075} =\right)$ 9·18 per centum.

From the foregoing it appears that the resistance due to screw E, when revolving freely, is 27·89 per centum of the resistance of the vessel, *per se*, less than when it is held stationary with two of its blades in the vertical position behind the vessel's stern-post, and the remaining two in the horizontal position, square across the vessel; and 32·17 per centum less than when it is held stationary with its blades at the angle of 45 degrees with the horizon.

Results with screw F.—This screw (sometimes called the Mangin screw and sometimes the duplex screw) was four-bladed, and consisted of two pairs of blades placed immediately behind the other, so that when viewed in projection on a plane at right angles to axis, it appeared as a two-bladed screw with the blades directly opposite each other. Each blade was exactly the same as one of the blades of screw C, so that screw F had the same kind of surface as screw C, and just double the quantity.

With the blades of screw F held stationary in the vertical position, immediately behind the stern-post of the vessel, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour was 721 pounds; deducting from which the 631 pounds due to the resistance of the vessel there remain for the resistance of the screw, *per se*, 90 pounds. Consequently, the screw, with its blades in the vertical position, increased the vessel's resistance $\left(\frac{90 \times 100}{631} =\right)$ 14·26 per centum, and decreased its speed ($\sqrt{631} : \sqrt{721} :: 7 : 7{\cdot}4826$; and $7{\cdot}4826 - 7 =$) 0·4826 geographical mile, or $\left(\frac{0{\cdot}4826 \times 100}{7{\cdot}4826} =\right)$ 6·45 per centum.

With the blades of screw F held stationary in the horizontal position, square across the vessel, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour was 851 pounds; deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 220 pounds. Consequently, the screw, with its blades in the horizontal

position increases the vessel's resistance $\left(\frac{220 \times 100}{631} =\right)$ 34·86 per centum, and decreased its speed ($\sqrt{631} : \sqrt{851} :: 7 : 8{\cdot}1292$; and $8{\cdot}1292 - 7{\cdot} =$) 1·1292 geographical miles per hour, or $\left(\frac{1{\cdot}1292 \times 100}{8{\cdot}1292} =\right)$ 13·89 per centum.

From the above it appears that screw F, when its blades were held in the horizontal position, square across the vessel, had $\left(\frac{220}{90} =\right)$ 2·444 times the resistance it had when its blades were held in the vertical position, immediately behind the vessel's stern-post.

When screw F was allowed to revolve freely by the pressure of the water on the forward face of its blades, it made 921 revolutions per geographical mile, which number was not affected by the speed of the vessel, but remained constant for all speeds from $5\frac{1}{2}$ to 7 geographical miles per hour. The axial speed of the screw was consequently $\left(\frac{6086 - 5{\cdot}136 \times 921 \times 100}{6086} =\right)$ 22·28 per centum less than the speed of the vessel, and when the latter was 7 geographical miles per hour, the screw was dragged bodily through the water at the speed of 1·559 geographical miles per hour. The revolutions of this screw were uniform, and there was no appearance of hesitation when the blades came into the vertical position behind the stern-post of the vessel.

With the vessel at the speed of 7 geographical miles per hour, and screw F revolving freely, the aggregate resistance of vessel and screw was 698 pounds, deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 67 pounds. Consequently, the screw, when revolving freely, increased the vessel's resistance $\left(\frac{67 \times 100}{631} =\right)$ 10·62 per centum, and decreased its speed ($\sqrt{631} : \sqrt{698} :: 7 : 7{\cdot}3623$; and $7{\cdot}3623 - 7{\cdot} =$) 0·3623 geographical mile per hour, or $\left(\frac{0{\cdot}3623 \times 100}{7{\cdot}3623} =\right)$ 4·92 per centum.

From the foregoing it appears that the resistance due to screw F when revolving freely is 3·64 per centum of the resistance of the ves-

sel, *per se*, less than when it is held stationary with its blades behind the stern-post in the vertical position; and 24·24 per centum less than when it is held stationary with its blades in the horizontal position square across the vessel.

Results with screw H.—This screw has a large globular hub, and three blades cut to the pear-shape, which forms the Griffith screw. It has the same diameter as the previously-described screws, but its pitch is greater and expands gradually from the forward to the after edge of the blades.

With the blades of screw H held stationary in such position that one blade was vertical *below* the shaft and immediately behind the stern-post of the vessel, the remaining two blades being *above* the shaft and at angles of 60 degrees with the perpendicular, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour, was 914 pounds, deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 283 pounds. Consequently, the screw, with its blades in the above position, increased the vessel's resistance $\left(\frac{283 \times 100}{631} =\right)$ 44·85 per centum; and decreased its speed ($\sqrt{631}$: $\sqrt{914}$ :: 7 : 8·4247; and 8·4247 — 7·=) 1·4247 geographical miles, or $\left(\frac{1{\cdot}4247 \times 100}{8{\cdot}4247} =\right)$ 16·91 per centum.

With the blades of screw H held stationary in such position that one blade was vertical *above* the shaft and immediately behind the stern-post of the vessel, the remaining two blades being *below* the shaft and at angles of 60 degrees with the perpendicular, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour was 992 pounds, deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 361 pounds. Consequently, the screw with its blades in the above position, increased the vessel's resistance $\left(\frac{361 \times 100}{631} =\right)$ 57·21 per centum; and decreased its speed ($\sqrt{631}$: $\sqrt{992}$ :: 7 : 8·7768; and 8·7768—7·=) 1·7768 geographical miles, or $\left(\frac{1{\cdot}7768 \times 100}{8{\cdot}7768} =\right)$ 20·24 per centum.

When the blades of screw H held stationary in such position that one blade was horizontal, square across the vessel on one side of the stern-post, the remaining two blades being on the opposite side of the stern-post and at angles of 30 degrees with the perpendicular, the aggregate resistance of the vessel and screw at the speed of 7 geographical miles per hour was 962 pounds, deducting from which the 631 pounds due to the resistance of the vessel, there remain for the resistance of the screw, *per se*, 331 pounds. Consequently, the screw with its blades in the above position, increased the vessel's resistance $\left(\frac{331 \times 100}{631} =\right)$ 52·46 per centum; and decreased its speed ($\sqrt{631} : \sqrt{962} :: 7 : 8{\cdot}6431$; and 8·6431—7.=) 1·6431 geographical miles, or $\left(\frac{1{\cdot}6431 \times 100}{8{\cdot}6431} =\right)$ 19·09 per centum.

From the above it appears that screw H, when one of its blades was held stationary in the vertical position *above* the shaft immediately behind the stern-post of the vessel, had $\left(\frac{361}{283} =\right)$ 1·276 times the resistance it had when its blades were held in exactly the reverse position, that is to say, when one of its blades was vertical *below* the shaft immediately behind the stern-post. When one of the blades was held horizontly, square across the vessel on one side of the stern-post while the other two blades were on the opposite side at angles of 30 degrees from the perpendicular, the resistance of the screw (331 pounds) was but a little over the mean $\left(\frac{283 \times 361}{2} =\right)$ 322 pounds of its resistances with one blade vertical alternately above and below the shaft.

When screw H was allowed to revolve freely by the pressure of the water on the forward face of its blades, it made 665 revolutions per geographical mile, which number was not affected by the speed of the vessel, but remained constant for all speeds from $5\frac{1}{2}$ to 7 geographical miles per hour. The axial speed (for mean pitch) of the screw was consequently $\left(\frac{6086 - 7 \times 665 \times 100}{6086} =\right)$ 23·51 per centem less than the speed of the vessel, and when the latter was 7 geographical miles per hour, the screw was dragged bodily through

the water at the speed of 1·6459 geographical miles per hour. The revolutions of the screw were uniform, and there was no appearance of hesitation when the blades came into the vertical position behind the stern-post of the vessel.

(To be continued.)

ATMOSPHERIC GAS ENGINES.

The explosive gas engine is a well-known machine, and although it met with little success in this country, in the form of engine constructed after M. Lenoir, it has maintained its place in Europe as a source of motive power since 1866. Another engine of a similar type to that of M. Lenoir has also met with a measure of favor in Europe, but neither of these two engines have been quite satisfactory in service.

From a paper prepared by Mr. Francis W. Crossley, and read before the Institute of Mechanical Engineers, at Manchester, England, it appears that some considerable improvement has been affected by Messrs. Otto & Layer. The main characteristic of the new engine is the *free piston*. The engine is really a gun, which stands vertically with open mouth, pointing upward; the explosive compound of air and gas, is, however, not sufficient to drive the piston out of the cylinder, but only to within one or two inches of its mouth.

The piston rises freely and the motive power is derived from its weight (which is very small, however, for it is desired that the gases should expand to their utmost) and from the atmospheric pressure acting upon its upper surface, with the partial vacuum which follows the explosion, below it. In all the gas engines previously constructed, the force of the explosion has been the motive power. The effect of delivering this sudden blow against a piston, connected rigidly with a heavy fly-wheel, has been simply that instead of the heat, which is set at liberty by the union of the oxygen and hydrogen in the explosion, being converted into mechanical motion, it remains in the form of heat, and has to be got rid of by a very large external supply of cold water, lest it should destroy the surfaces of the cylinder and piston, and even lead—as it has often done—to the buckling of the piston-rod when it has grown red hot.

The blow given to the piston by the explosion has been received by the heavy mass of the necessarily heavy fly-wheel, which cannot rapidly yield to it: and just as when a cannon-ball strikes a massive target

which it cannot carry along with it, a flash of fire is the result in which the energy of the shot disappears, so in these engines heat instead of motion has been the result of the release of the stored energies of the gases.

The flame of carburetted hydrogen, when combustion is perfect, is intensely hot, and when repeated discharges take place—say 150 a minute—it is easy to see how much cold water must be circulated through the jacket of the cylinder to keep the temperature down to below that at which oil oxidizes, in order to prevent the destruction of the piston. It has been found possible, however, to keep the temperature sufficiently low even in these engines by supplying enough water, but it has taken a great deal, and where constant working is required; much has been added to the cost of running, and all the heat taken up by the water is carried off without doing work.

The difference in consumption of gas for the same power is found to be about as 1 to 6 in favor of the new engine, and as the cylinder in which this is burnt is also about 4 to 1 in volume, there is 24 times the space per unit of gas consumed relatively to the others. This leads to a less liability to clog from deposit, and to become equally dirty the engine would require 24 times as many hours' work.

The following abbreviated description will serve to give an understanding of mechanical contrivances adopted:

The piston-rod is a rack, and gears into a toothed wheel on the main shaft of the engine, which is mounted on the top of the cylinder. The length of the rack is about equal to twice the circumference of the wheel, so that the single-acting character of the engine is very different in its effect from what it would be in a steam-engine. The toothed wheel referred to is, however, not keyed fast upon the shaft, but is attached to it by a roller-pawl clutch, which permits the piston and rack to rise without moving the shaft at all, and connects them on the down stroke only. Thus the shock of the explosion is not sustained by the shaft, and the piston is able freely to move away from it, being arrested only by the resistance of the atmosphere at the upper end of the stroke.

The series of operations in each stroke, commencing with the piston at the bottom is:—First, the piston is lifted through a space of about 1-11th of the length of stroke, in order to draw in the charge of gas and air, and the power to affect this movement, is obtained from the momentum of the fly-wheel. The charge is then fired by contact with a gaslight, and the piston flies up freely to the top.

As it ascends, the plenum caused by the explosion is changed to a partial vacuum, which reaches to about 22 inches of mercury at the top of the stroke, and thus the motion of the piston is quickly reversed, and the down-stroke is performed under a pressure of about 11 pounds per inch derived from the atmosphere, and this driving power is communicated through the rack and wheel to the shaft. When the piston has reached within a short distance of the bottom, the vacuum, which has been gradually decreasing, is again exchanged for a plenum, and the weight and momentum of the piston and rack expel the burnt gases during these last few inches of the stroke.

The valves for admission of gas and of air have ports adjusted for proportioning the explosive mixture, and are worked by the obvious means of tappets or eccentrics, and the speed of the engine is regulated by a governor which acts upon the exhaust valve on the one hand and upon the supply (or explosion mixture) valve on the other.

But the most interesting question is the consideration of the engine from a purely scientific point of view. How many foot pounds are obtained on the brake per heat unit supplied by the fuel? Here the best steam-engines are surpassed by this gas engine. Were pure hydrogen the fuel instead of adulterated coal gas, no less than two-fifths of the theoretic efficiency of the fuel might be realized on the brake; coal gas, however, is less productive. Taking the proportion of gas to air for complete combustion as 1 volume of gas to 6¼ volumes of air, and the theoretic efficiency of the gas as equal to 24,113 heat units per pound weight consumed, one heat unit being equal to 772 foot pounds, and taking the density of the gas as 40 per cent. that of air, or 1 cubic foot of gas = 0·0305 pound in weight, then the heat units supplied to the engine per minute are 595,686, and the return for this on the brake is, say, 70,000 foot pounds, or 12 per cent. To compare this with the best steam engine, allowing for air-pumps and feed-pumps and friction, is it not even too much to say that 2 pounds of coal will give, under the most favorable conditions of a trial trip, 1-horse power per hour on the brake? Taking it at that figure, and taking the 1 pound of coal to supply 15,224 heat units, (an assumption of heat from coal which may be excessive, but which is coincident to the production of a horse-power from 2 lbs. of coal,) or 11,752,928 foot pounds, then $\frac{33{,}000 \times 60}{2} = 990{,}000$, or but 8½ per cent. of the theoretic efficiency of the fuel, while the gas engine realizes 12 per cent., or nearly one and one-half times the amount.

QUADRUPLEX TELEGRAPHY.

By S. M. Plush.

There exists some doubt as to the origin of duplex telegraphy; some refer it to Dr. Gintl, in 1853.

It is certain, however, that experiments were made by the Electric Telegraph Company of England, in 1853; by Gintl, Siemens and Frischen, of Russia, about the same time; by De Sauty, in England, in 1855; and by the Magnetic Telegraph Company, between London and Birmingham, in 1856; but owing to various difficulties, not then to be overcome, the system was for the time abandoned, no advantageous results over the single method having been obtained.

It remained for J. B. Stearns, of Boston, in 1868, to make the duplex of practical importance, and he undoubtedly stands in the same relation to the duplex as Morse does to the single system.

While neither Morse nor Stearns perhaps were entitled to the credit of the discovery of the principles upon which their inventions were based, nor the fundamental laws by which they were controlled, still by a knowledge of these, and a proper combination and application of various mechanical appliances, some new, some old, instantaneous communication became a reality, whereas it was before a dream; and things that were seemingly impossible, were no longer so, as in double transmission on one wire. We cannot consistently withhold the credit from these men whose efforts have converted our scientific toys into instruments of usefulness, whereby our commerce and finance are enriched, and social pleasures enhanced *two*, yes, *fourfold*.

In 1872, the American Institute of New York, after a most careful and exhaustive examination, awarded the Great Medal of Honor to Joseph B. Stearns, for the invention of the Duplex Telegraph. Being the second of this class of medals issued since its foundation; the conditions upon which they were awarded being such as to exclude all inventions and improvements except those of paramount importance.

The Differential Duplex, as perfected by Stearns in 1868, consists of an improved transmitter or key, with double contact points, and more

recently, condensers, whereby the difficulties attending long circuits were entirely overcome, and the working capacity doubled. The helix is composed of two wires of equal lengths and resistances, the outer end of one and the inner end of the other being brought in direct contact with the key, one of the distant ends of these wires is connected to the earth through coils of the same resistance as the line. The transmitter is an ordinary Morse key, having two contacts, one with the battery when the lever is depressed, and the other with the earth when elevated, one contact invariably being made by spring connection *before* the other is broken. Thus the line is always to earth, either through the battery or direct. By depressing the key at one station, contact is made with the battery; the current dividing equally, passes through each coil of the relay at such station, in opposite directions. The magnetic power of each being equal, and of opposite polarity, produces no effect on the armature, while a current sent from the distant station passes through one coil only, and affects the armature corresponding to the signals sent. When both stations are sending, double the quantity of electricity which passes through the resistance coils, is passing through the line coil at either end. The cores of both relays therefore become magnetized by this difference, and signals are recorded simultaneously at both stations.

When this system of duplex was first tested on long lines, a very serious difficulty presented itself, caused by the discharge of return currents through the relay; being proportionate in volume to the static capacity of the line. *Electricity invariably follows the channel of least resistance to earth;* while in a long and well insulated conductor of large metal cross-section, electricity will flow through to the distant end, and to ground, so long as battery power is maintained; if ground contact be suddenly substituted for this, part of the charge left in the conductor at that instant, will return to the ground in preference to overcoming the resistance intervening between it and the distant ground.

The use of the condenser is to obviate this, by furnishing an additional static capacity, equal to that of the line; and by this means, circuits of several hundreds of miles can be successfully worked.

A condenser is an apparatus by means of which, a large quantity of electricity can be gathered on a small surface. Its form may be greatly varied, but the essential points consist of two good conducting surfaces, separated from each other by a non-conducting surface.

The charge depends on the size of the surfaces of the non-conductor placed between the condenser plates; on the tension of the electricity which furnishes the charge; on the distance between the metallic plates, and on their size. They are usually constructed of thin sheets of paper, saturated with paraffine, and covered on both sides within a short distance from the edge with tinfoil; they are then laid singly, one upon the other, like the pages of a book; the tinfoil plates being connected together in two series, upper and under. In this manner two separate rows of metallic plates are formed, separated by the paraffined paper, and presenting a large surface in a small space.

A rheostat is a combination of measured or known resistances, so arranged, that any desired amount can be put in circuit or removed at pleasure; the ends of the several resistances are connected to brass discs, which can be connected or disconnected by simply removing the metallic pins that connect these discs together. When the pins are in, an electric connection is formed from one disc to another; when they are out, this connection is broken, and the current obliged to pass through that portion of resistance corresponding to the discs. The resistance coils, as a rule, are wound with German silver wire; the specific resistance of which metal is but slightly affected by temperature.

Rheostats being composed of fine wire of a highly resisting material, have not the static or charge capacity of a long line; the metal of the one, weighing a few ounces only, that of the other, many tons of good conducting substance. No return charge, therefore, is felt from the rheostat. By connecting to the rheostat a condenser of equal static capacity to that of the line, a charge will be returned from it, simultaneously with that from the line, one balancing the other, and preventing any tendency to magnetize the cores of the relay. This system of duplex can be worked equally well with either pole of the battery to the line. When both stations use currents of the same polarity, they oppose each other midway, allowing the currents in the rheostat coils of the relays at the sending stations to influence the relays, the same as if both currents combined on the line.

The Bridge duplex (Stearns' more recent invention, on which the Quadruplex is based), is founded on the Wheatstone Bridge or balance principle. This method consists in the combination of the receiving instrument or relay with resistance coils, so that when a current is

transmitted from one station, it does not pass through the receiving instrument at that station, but directly to the line; the instrument at this station responding only to the currents sent from the distant station. Any kind of receiving instruments may be used in lieu of the relay.

When a current is divided between two circuits which are connected by a cross-wire or bridge, no current will pass through the bridge, provided the resistance of the opposite circuits on each side of the bridge are equal, or are in the same ratio to each other.

Fig. 1 will materially assist in comprehending the principle upon which this method is based. When the key (K) is closed, the current thus sent to the line will divide at H, one part flowing through the line, via A, the other through the resistance coils (R) to earth (g) via B, in the proportion of their respective conductivities. (Conductivity being the reciprocal of resistance.) Now, if the combined resistance of A and L be equal to that of B and R, no current will pass through the bridge wire, or if the resistance of the branch A, bears the same *proportion* to that of L, that B does to R, then no current will pass through the bridge. For example, suppose the resistance of A to be 500 ohms, L 2,000, B 250, and R 1,000, then no current would pass through the cross-wire, because the two circuits A and B are in the same proportion to each other, as L is to R. When the current reaches the distant station, it divides at F; one portion going to earth, via A and K, and the other to earth, via rheostat R, in the inverse ratio of their respective resistances. The instrument being placed between the points F G, is influenced by that portion, and thus records the signals. When, however, a current from the distant station is put on the line, the quantity of electricity on the line is doubled; but only the part supplied from either end, finds its dividing point at the distant point F, a portion passing through each bridge, thus effecting the relays, and recording the signals.

Figures 2 and 3 represent the rheostat and transmitting sounder in use in the bridge duplex. Fig. 2 contains the condenser plate, adjustable resistances and binding screws, for connecting the apparatus. The central disc is connected to the condenser, by binding screw C; the inner circle of discs is connected to earth, by binding screw E, and is attached to resistance coils of 1,000, 2,000, and 4,000 ohms each, corresponding with rheostat R, in Fig. 1. The outer circle of discs, corresponds with rheostats A and B, in Fig. 1,

FIG. 1

FIG. 2

FIG. 3

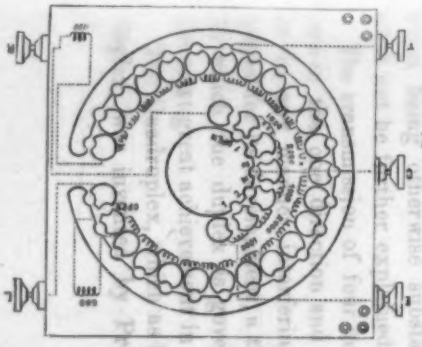


FIG. 1

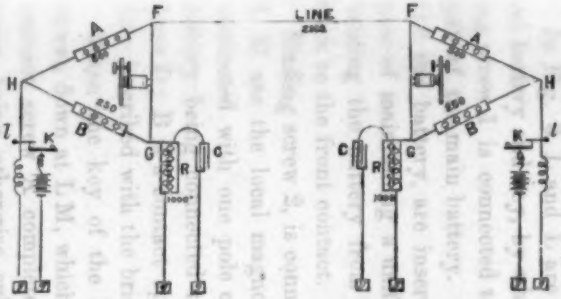


FIG. 2

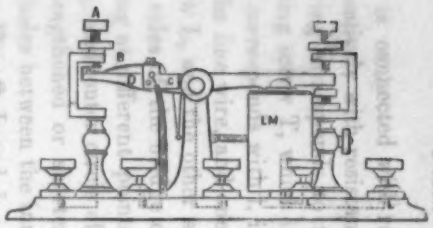
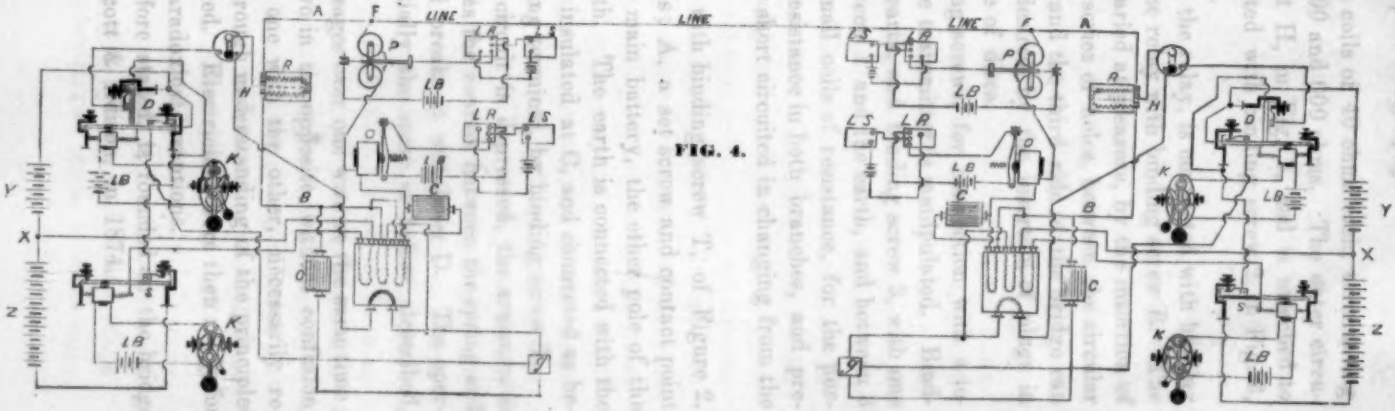
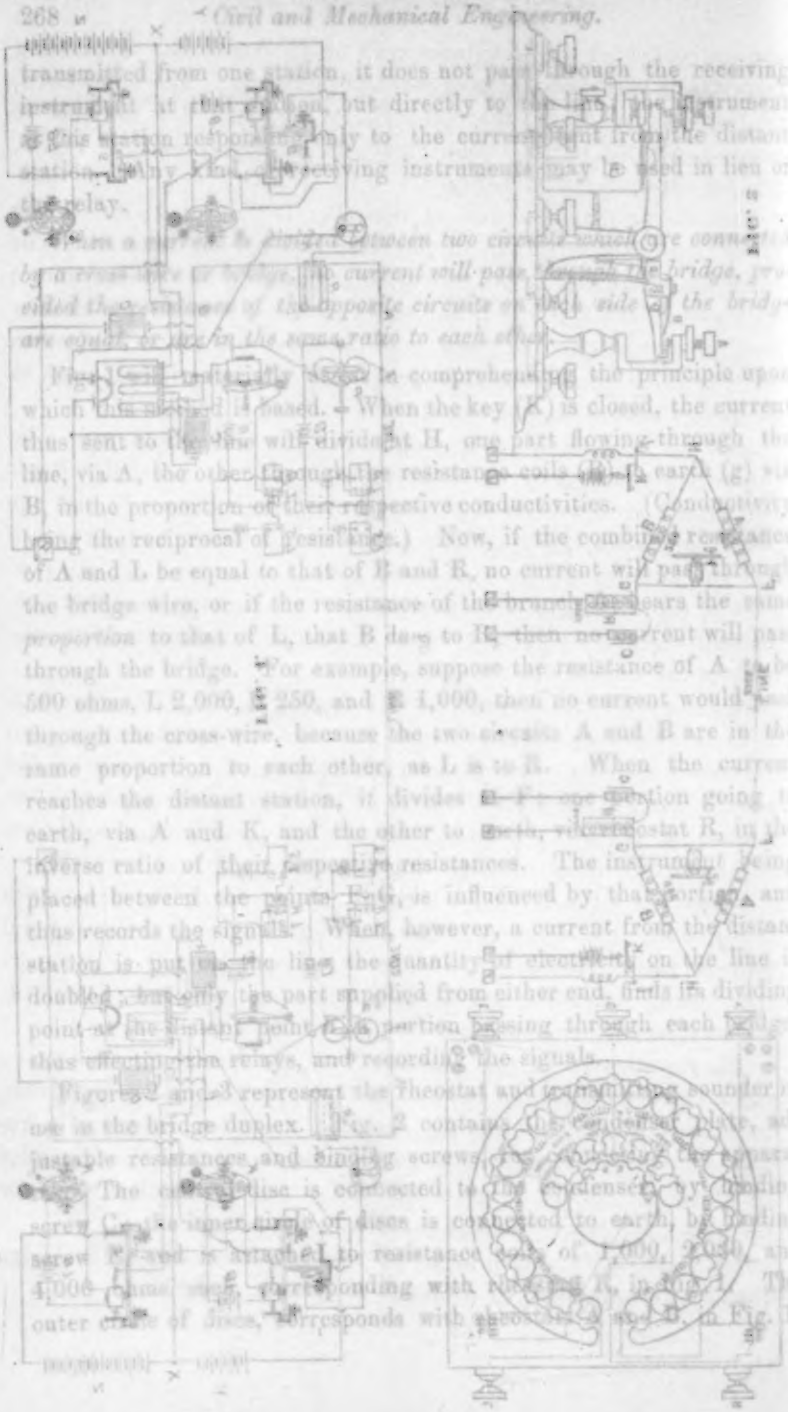


FIG. 4.





transmitted from one station, it does not pass through the receiving instrument at that station, but directly to the line. The instrument at this station responds only to the current sent from the distant station. Any kind of receiving instrument may be used in lieu of the relay.

When a current is divided between two circuits which are connected by a cross wire or bridge, no current will pass through the bridge, provided the resistance of the opposite circuits on each side of the bridge are equal, or else in the same ratio to each other.

Fig. 1 will readily assist in comprehending the principle upon which this system is based. When the key (K) is closed, the current thus sent to the line will divide at H, one part flowing through the line, via A, the other through the resistance coils (R) to earth (g) via B, in the proportion of their respective conductivities. (Conductivity being the reciprocal of resistance.) Now, if the combined resistance of A and L be equal to that of B and R, no current will pass through the bridge wire, or if the resistance of the branch circuits bears the same proportion to that of L, that B does to R, then no current will pass through the bridge. For example, suppose the resistance of A to be 500 ohms, L 2,000, B 250, and R 1,000, then no current would flow through the cross-wire, because the two circuits A and B are in the same proportion to each other, as L is to R. When the current reaches the distant station, it divides at F, one portion going to earth, via A and K, and the other to earth, via rheostat R, in the inverse ratio of their respective resistances. The instrument being placed between the points F and H, is influenced by that portion, and thus records the signals. When, however, a current from the distant station is put on the line, the quantity of electricity on the line is doubled; but only the part supplied from either end, finds its dividing point at the same point, the portion passing through each bridge, thus effecting the relays, and recording the signals.

Figures 2 and 3 represent the rheostat and recording counter in use in the bridge duplex. Fig. 2 contains the condenser plate, adjustable resistances, and binding screws. The [illegible] The outer line is connected to the condenser by binding screw C, the inner ring of discs is connected to earth by binding screw E, and is attached to resistance coils of 1,000, 2,000, and 4,000 ohms each, corresponding with those in R, in Fig. 1. The outer circle of discs corresponds with [illegible] in Fig. 1.

and is connected with resistance coils of 40 ohms each, terminating respectively with resistances of 400 and 600 ohms. The outer circular ring corresponds to the point H, in Fig. 1, and is attached to binding screw T, which is connected with binding screw 2, in Fig. 3, and corresponds with 1, in Fig. 1.

The line wire, and one side of the relay, is connected with binding screw L, and the other side of the relay with binding screw R. The two sides of the bridge can be varied at pleasure, by the insertion of a plug at different points in the series of holes, between the circular ring, and outer circle of discs; and the third side of the bridge can be lengthened or shortened as desired, by the insertion of plugs in the holes between the inner circle of discs.

In Fig. 3, L and L are binding screws, for connection with a local battery and key, by which the transmitter is manipulated. Binding screw 1 is connected to the earth, and binding screw 3, with one pole of the main battery. Between 1 and the earth, and between 3 and the battery, are inserted small coils of resistance, for the purpose of maintaining a uniform resistance in both branches, and preventing the battery from being short circuited in changing from the back to the front contact.

Binding screw 2, is connected with binding screw T, of Figure 2. L M are the local magnet coils; A, a set screw and contact point connected with one pole of the main battery, the other pole of the battery being connected to earth. The earth is connected with the lever D; B is a contact spring, insulated at C, and connected as before described with the bridge ring terminal, by binding screw T.

When the key of the local circuit is depressed, the armature is drawn down at L M, which makes the contact between the spring and contact screw A complete, and breaks it with lever D. The operation being otherwise substantially the same as before described, need not be further explained.

The transmission of four messages over one wire at the same time; two in the one direction and two in the opposite, without confusion, or in any manner interfering one with the other, necessarily required for its development, a thorough understanding of the principles by which the duplex is governed. Electricians were then ready for the next great achievement in paradoxical inventions.

The Quadruplex, which as before stated, is founded on the bridge duplex, was invented by Prescott & Edison, in 1874.

[Other methods of the quadruplex have been brought to notice. That of M. Meyer, of the French Telegraph Administration, transmitting four messages over one wire in the same direction, and that of Dr. Nicholson, of Ohio, based on the differential principle. But as they have not yet proved of practical value, a description would be of slight interest here.]

According to their system, it is necessary at each station to have two transmitters and two receiving instruments, so arranged, that when one transmitter is closed, the corresponding receiving instrument only, at the other station, will respond. When the other transmitter is closed, *its* corresponding receiving instrument responds; and when both transmitters are closed at the same time, *both* receiving instruments respond; the receiving instruments at the sending station remaining unaffected by these operations, and ready to be influenced by similar manipulations at the other end. In order to accomplish this, two relays are placed in the bridge wire; one a common relay of short cores, low resistance and counteracting spring, capable of being affected only by strong currents; the other a Siemens' polarized relay of high resistance, and sensitive to feeble currents. The polarized relay is arranged with a closed stop in front, and an open stop back, in such a manner as to allow the tongue of the armature to make contact with one or the other, as the armature may be affected by the polarity of the current passing through the coils.

The common relay is provided with similar stops, having its closed stop on the spring side. Each relay is provided with two local batteries, one of which is connected through the relay points, and the coils of a local relay, which local relay is provided with contact points, so arranged as to close with the open circuit, or upward movement of the armature; this of course reverses the signals. The other local battery is connected through these points and the coils of the local sounder, which again reverses the signals, making them normal. (Fig. 4.)

One of the transmitters is a pole changer, having one spring connected to the line, and the other to the ground. The smaller portion of main battery is connected crosswise with the contacts of each spring, through the spring and lever of the single transmitter, which has an additional section of battery inserted between the lever and and its closing contact points. The movements of the double transmitter entirely determine the polarity of the current sent to line.

The other transmitter merely cuts in or out of circuit, an increased portion of battery—sufficient to close the common relay at the distant end.

By reference to Fig. 4, (which is an exact representation of the quadruplex, as in use by the Western Union Telegraph Company), it will be seen that the main battery is divided at X, (the division usually being as one to three); the smaller portion, Y, being connected to the double transmitter or pole changer, D; the larger portion, Z, to the single transmitter, S. Both transmitters are placed in a local circuit (L B) and manipulated by an ordinary Morse key (K). When both transmitters are open, the smaller portion of the battery will be presented to the line, through the double transmitter, (D), its currents will divide between the sides of the bridge at the point H, one portion passing through A, over the line, the other through B, via R, (rheostat) to ground. That portion passing over the line will divide at the distant point, F, one portion passing through A to key and earth, the other through the bridge wire and relays to earth. This current will influence the armature of the polarized relay (P) causing it to rest on the front or closed stop; but is not of sufficient strength to affect the common relay (O).

This same portion of battery is reversed by closing the double transmitter, which will reverse the movements of the polarized relay, causing its armature to rest on the back or open stop, and the local sounder, L S, responds. Still the common relay, O, is not visibly affected, though both currents have traversed its coils; but when the single transmitter, S, is closed, the full force of all the batteries is brought into action; that portion passing through the relays is now sufficiently powerful to attract the armature of the common relay, O, and the corresponding sounder speaks. The single transmitter cannot record a signal on the polarized relay when the double transmitter is open, because the current is of the wrong polarity—as before stated, the double transmitter determines the polarity of the current sent to line —if open, one pole of the battery is presented—if closed, the other, the single transmitter merely increases or diminishes the amount. The same results are obtained at the home end by similar manipulations at the other.

For reasons already explained, the bridge wire is provided with a condenser, C, charged by the relay currents. When the current is withdrawn from the relays, the condenser discharges before a re-

versed current reaches them, thereby prolonging the signals and maintaining a magnetic equilibrium of the cores.

The strength of current passing through the bridge relays, can be increased or lessened at pleasure. It not being necessary that both sides of the bridge shall be equal to each other, but that they should be in the same ratio, as explained when treating of the duplex.

The complexity of the apparatus, and the accurate adjustments necessary to utilize its full working capacity, require great skill and careful management. The officers of the Western Union Telegraph Company have proved themselves entirely *au fait*, and the quadruplex is now in daily successful use between the more important points of telegraphic communication in the United States. The distant points working direct with each other through intermediate repeaters.

For example, the circuit from New York to Chicago (nearly one thousand miles) is worked with repeaters at Buffalo. When desired, this circuit can be divided at Buffalo (by switches with which each complete set of instruments is provided) in such a manner as to allow New York to send to, and receive from Chicago, and Buffalo to send to, and receive from both Chicago and New York. Thus giving the capacity of one wire to, and from each of the points named.

When it is considered that by this system in addition to quadrupling the capacity of a wire, enabling communication direct with stations far distant—whose amount of business would not warrant the maintenance of a wire for that purpose alone, and allowing half the capacity of the wire to be used in sections if desired, for the benefit of intermediate stations, there is saved the investment for the cost of additional wires, and the liabilities to troubles, where many wires are crowded upon one line of poles, an indefinite idea may be formed of the value of this wonderful invention.

The perfection to which the telegraph has so rapidly approached, has virtually annihilated time and distance; is aiding the enforcement of the laws, and bringing the nations of the earth in more harmonious relationship—making all mankind friends, and the bond of union which civilization is each day riveting, a safeguard against future discord.

East, West, North and South—all are within the speedy reach of the lightning messenger, through whose invisible manœuvres, the untiring signals of the telegraph breathe the wishes of the world,

news of national or financial import, and tidings of joy or grief with unerring promptness.

The news of yesterday in the old world, becomes the theme of conversation to-day in the new; thus completing the triumph of science, and the testimony of success to energy and perseverance.

Photometry by Electricity.—Dr. Werber Siemens, in a paper read to the Verein für Gewerberfleiss, proposes a method of photometry measured by electrical currents.

The comparatively scarce, elementary substance *selenium* is quite nearly allied to sulphur, and, like sulphur, has amorphous forms, crystallizing on different systems at certain temperatures.

Amongst the properties of the amorphous crystals was one discovered by Lieut. Sales, that these crystals would conduct electricity better when illuminated than when in darkness.

This property was found to be permanent; that is, no permanent alteration of conductive power ensued from exposure to light, and the selenium returned to its original condition of conductivity upon removal of the ray. Heat, also, was effective in influencing the conducting power, and the effect of the heat decreased as the temperature increased, by some ratio, not stated.

Dr. Siemens has found a second amorphous condition for selenium crystals, formed at a somewhat higher temperature (we take these crystals to be opaque), in which the effect of heat on the conductivity is to increase the conductive power in place of decreasing it.

He encloses some coarsely crystallized selenium, of this second condition, between flat spirals of wire on two sides, and leaves of mica on the other sides, and by means of a battery or other source of electricity, has succeeded in transmitting sufficiently strong currents in the wire to indicate even weak intensities of light. Assuming the permanency of this property of selenium and the instantaneity of the recurrence of the change of conductivity, it would appear that we have at last an accurate register of comparative intensity, measurably, if not entirely devested from the effect of color, (which has impaired the visual methods,) and if the effect of heat can be diminished (or reduced to estimable comparative value); a perfect photometer.

This discovery is too important not to command attention, and the further development will be looked for with the greatest interest.—Extracted from the *Electrical News*, August 19th, 1875.

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.*

By Dr. A. W. Hofmann.†

[Continued from Vol. lxx, page 134.]

This report resulted from the minute investigations of MM. Péligot, Lamy, Troost, De Mondésir, and Le Blanc, who had been appointed as commissioners by the Prefect of the Seine in 1869. They undertook an examination of the process in the Place de l'Opera as well as in the laboratory. They burnt ordinary gas, boghead gas, and gas saturated according to different systems with liquid hydro-carbons, along with about half its volume of oxygen, and making use of various burners. They came to the conclusion that, for an equal intensity of light, the process of Tessié du Motay is almost always dearer—generally twice as dear—as the ordinary mode of lighting. In one case only, where the liquid hydrocarbons of the Boghead coal were used for carburetting by absorption in wicks, according to the plan of Levêque, over which the gas passed, it was found that the new process was twice as cheap as the ordinary method. This, moreover, applied only to the use of large burners, and the consequent production of great quantities of light. All the figures given by Tessié du Motay's Company, as to the cost of oxygen and the expense of carburetting, were taken for granted. In fact, however, it appeared that, in this experiment, 1 cubic meter of gas took up, not 50 grms. of liquid hydrocarbons, as the Company stated, but 266 grms., which rendered the economy of the process at any rate doubtful. As regards the strength of the light, the commissioners found it from three to seven times greater than that of common coal-gas. But Boghead gas in suitable burners can be made to yield a light three times

* "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

† From the *Chemical News*.

stronger than that of coal-gas without the aid of pure oxygen. For most purposes, moreover a very great intensity of light is not desired as we see it reduced to 30 per cent. by means of glass shades and screens.

The conclusion of the commission, therefore, was to advise the municipality of Paris not to permit the laying down of mains for oxygen gas, but to leave it to the company to furnish oxygen and carburetted gas in portable gasometers to such persons as required an intense light.

The results obtained in Brussels were not more favorable. Lighting with oxygen was tried there last year for a short time in some coffee-houses and in the Passage St. Hubert, and given up on account of the above-mentioned disadvantages.* In Vienna, in April, 1874, the Westbahnhof was still lighted up with oxygen; but the system had made no further progress in that city, and the bluish moon-like light, in spite of its intensity and beauty, as represented above, was regarded as unsatisfactory.† The jury of the Vienna Exhibition examined the oxygen illumination at the Westbahnhof (Western Railway Terminus.) In the Exhibition itself the manufacture of oxygen was not represented.

Should further experience confirm these decisions, the manufacture of oxygen would be deprived of its present foundations. For it has been undertaken solely in the hope of the application of the oxygen to lighting purposes.

Many of the above-mentioned disadvantages, and especially the cost of the mains, are evaded in the arrangement which Phillips‡ proposes for oxygen illumination. This depends on lamps (manufactured by Berghausen, of Cologne), fed from an oil-cistern with very heavy tar-oil, rich in naphthalin, whilst oxygen is introduced into the centre of the wick. Whether great cities will be induced to give up the advantages of gas-lighting in favor of this arrangement, and whether it is practicable on the large scale, must be considered very doubtful.

The more we must hope that the manufacture of oxygen may be saved by the metallurgical demand. In medicine it has not found

* Letters from M. Melsens, Professor of Chemistry in Brussels, to Professor A. W. Hofmann, April 14th, 1874.

† Verbal communications from H. Hlasiwetz, Professor of Chemistry at the Polytechnicum in Vienna.

‡ Phillips, "Der Sauerstoff," Berlin, 1871, p. 46.

any general application. According to Pereira,* in spite of certain modern eulogies of the healing power of oxygen, there is, in the opinion of competent judges,† little to be said on the subject. We qrote the passage :—

"Soon after the discovery of oxygen gas, a strong feeling arose in favor of its medicinal applications. Various diseases, *e. g.*, scurvy, were ascribed to a deficiency of it in the system, and it was accordingly employed in many cases, and, as was at first declared, with brilliant results. In England, it was tried by Beddoes and Hill.‡ The latter declares that he found it useful in asthma, weakness, ulcers, gangrene, white swellings, and scrofulous affections of the bones. These views have been again abandoned, both on chemical and physiological grounds. In asphyxia, from want of air, or from the inspiration of pernicious gases, oxygen gas may be inhaled with advantage. From the same reason, it has been recommended in spasmodic asthma, attended with danger of suffocation. Still it is, at the best, a mere palliative, and can by no means prevent renewed attacks. If we consider, in the application of oxygen gas, its physical action, as already discussed, we shall readily conclude that the inspiration of oxygen is in most cases useless, and that but little—and only in few cases—can be expected from its therapeutical application.

Nevertheless, an "Inhalatorium," recently opened in Berlin, sells oxygen at 6 silver groschen per cubic foot (20 marks per cubic meter) and oxygenated water at 1½ silver groschen per bottle.§ As water 0° does not absorb 4 per cent. of its volume, a half-liter bottle does not contain 20 c.c., or 0·0017 grm., of the gas. To expect any effect from such a dose appears irrational.

Just as concentrated food is recommended for travelers, so oxygen has been proposed to be inhaled by those who climb the highest summits of mountains or attain altitudes in balloons where the rarefaction

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* Pereira, "Heil Mittel Lehre;" Buchheim's German edition, vol. i, p. 217.

† Verbal communication from Professor Oscar Liebreich.

‡ "Considerations on the Use of Factitious Air and on the Manner of Obtaining them in Large Quantities," by F. Beddoes and J. Watt; Bristol, 1794–95. It is well known that, in 1798, a Pneumatic Institute was founded at Bristol, in which the medicinal properties of gases were examined, and where Humphry Davy discovered the effects of nitrous oxide.

§ Eight silver groschen = four-fifths of a shilling sterling.

of the atmosphere occasions dangerous affections.* P. Bert† has exposed himself and others, in a suitable apparatus, to dilutions of air far surpassing that encountered at the greatest altitudes hitherto reached. The difficulty of breathing, and the symptoms of suffocation which appeared when the barometer indicated 300 to 250 m.m. were relieved, according to his account, by a single inspiration of pure oxygen. Dilution of oxygen with atmospheric air was found more advantageous than the pure gas; and on a balloon voyage which Croce-Spinelli and Sivel undertook from Paris, March 22d, 1874, they took with them mixtures of 45 and 75 per cent. of oxygen (and therefore 55 and 25 of nitrogen.) With the aid of this mixture they were able to conduct valuable physical observations at leisure, and without bodily inconvenience, at the height of more than 6000 meters; and although Glaisher succeeded, without this auxiliary, in attaining still greater heights, it cannot be denied that oxygen gas affords the means of exploring atmospheric regions hitherto unknown.

The physiological applications of oxygen lead us naturally to that modification which bears the name of ozone, with which, in the outset, high therapeutical hopes were connected.

The discovery made known by Schonbein, according to which the peculiar phosphorous odor accompanying the electrolysis of water was due to the evolution of oxygen in a state possessing heightened oxidizing properties, was received with great expectations, both in medicine and arts. Schonbein named this oxidizing principle ozone (from ὀζειν to smell), and he perceived its evolution, as Van Marum had already done in 1785, at least, as far as the odor is concerned, near the conductor of an electric machine when in action. He discovered subsequently that it was produced also during the slow combustion of phosphorus, and that it was present in the atmosphere in very perceptible traces. Observations of its occurrence increased very rapidly. Schonbein and others found that the peroxides of silver, barium, and hydrogen, in contact with sulphuric acid, evolved oxygen more or less strongly ozonized, the same property belonging also to the manganate, permanganate, and (according to Rammelsberg) the periodate of potash. The agitation of air with mercury, or with the precious metals in a state of fine division, or with powdered glass,‡ was also

* Fonvielle, "La Science en Ballon:" Paris, 1869.

† Bert, *Comptes Rendus*, 1874, p. 911.

‡ Andrews, *Nature*, 1875, p. 365.

found to be a means of ozonization. The ethereal oils, especially oil of turpentine, display this property in a high degree. Ozone was detected in the air current from a furnace-blast and in the oxygen expired by plants.

The means for its detection, in addition to the fact that 1 part of ozone imparts its peculiar odor to 500,000 parts of air, were found in the following reactions:—

Ozone liberates iodine from the iodide of potassium, iodic acid and potassic peroxide being simultaneously formed, and the solution, after the removal of the iodine, has an alkaline reaction. The presence of the free iodine is easily demonstrated by means of moist starch-paper, and the potash, or potassium peroxide, by litmus. Ozone bleaches indigo and colors freshly-prepared tincture of guaiacum a deep blue, turns paper brown which is saturated with salts of manganous oxide or thallous salts by the formation of higher oxides, oxidizes mercury at ordinary temperatures, and converts silver into black silver peroxide. Paper saturated with thallous oxide and exposed to ozone blues tincture of guaiacum, potassium-iodide, and starch before it turns brown. It was sometimes forgotten that the reactions with indigo, guaiacum, and iodide of potassium and starch are produced also by chlorine, nitrous and hyponitrous acid, and hence phenomena have been ascribed to ozone which were really due to one or other of these bodies.

Concerning the nature of ozone, opinion fluctuated for a long time. More than one eminent chemist held that it contained hydrogen. Marignac and De la Rive maintained the opposite view, which was finally demonstrated by Soret in 1863. The reason of the difference between ozone and ordinary oxygen became gradually intelligible. The first step was furnished by the observation of Andrews and Tait that ozonized oxygen if heated to 270°, was converted into common oxygen, increasing at the same time in volume, and that ordinary oxygen, if ozonized by silent electric discharge decreased in volume. This decrease in bulk corresponds to the quantity of the active oxygen absorbed by potassium iodide, so that if the volume, on ozonization, is decreased by $\frac{1}{n}$, then $\frac{1}{n}$ of the ozonized oxygen is absorbed by solution of potassium iodide. Ozone, therefore, appears indubitably as condensed oxygen. Odling's hypothesis that this condensation amounts to one-third, and that the molecule of ozone is larger by the

half than that of ordinary oxygen, its molecular weight being $O_3 = 48$, that of common oxygen being $O_2 = 32$, was approximately proved by Soret in 1865, and decidedly demonstrated by Brodie in 1871.* Soret added the discovery that ethereal oils, especially oils of turpentine and of cinnamon, absorb the whole amount of the ozone formed; consequently, not $\frac{1}{n}$, but $\frac{3}{n}$.

Ozone has never been obtained in a state of purity.

All chemical methods, as well as the electrolysis of water, yield it only very sparingly, since not merely reducing agents, but even oxidizers—all super-oxides for instances—re-convert ozone into ordinary oxygen. The example of barium super-oxide shows this in the following equation:—$O_3 + BaO_2 = 2O_2 + BaO$.

Connections of cork and caoutchouc cannot be used in an ozone apparatus, on account of their oxidisability. The electric spark has also a destructive action upon ozone. The best procedure for its preparation is, therefore, silent discharge with the aid of a Ruhmkorff's apparatus in induction tubes, filled with oxygen. The greatest contraction which Andrews and Tait observed in oxygen thus treated was one-twelfth. This, as has been shown above, amounts to the transformation of one-fourth of the oxygen present into ozone.

An instrument of this kind, of a simple construction, was described by Warner Siemens† in 1857. Brodie‡ has recently defended the claims of this eminent physicist in opposition to supposed recent inventors, especially Houzeau. Wills‖ gave the instrument a less fragile form, and with this modification it has been recently introduced into trade by the English mechanicians, Tisley and Spiller.§ It has the advantage that it can be cooled by the passage of a current of water. As Siemens recommended the application of the thinnest possible glass it remains to be decided whether the more solid form may not involve a reduction of the yield of ozone.

(To be continued.)

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*Brodie, *Proceedings of the Royal Society*, vol. xx, p. 472, 1872; Odling, "History of Ozone," *Proceedings of the Royal Institution*, 1872.

†Siemens, *Pogg. Ann.*, cii, 120.

‡Brodie, *Nature*, Feb. 18, 1874.

‖Wills, *Ber. Chem. Ges.*, vi, 769.

§*Nature*, viii (1873,) 148.

PNEUMATIC TELEGRAPHS FOR LONG DISTANCES.

Paper read at the Meeting of the Society of Civil Engineers of Paris, on the 4th of June, 1875.

By M. A. CRESPIN.

The pneumatic telegraph, whose origin dates from an already remote period, has during the last twenty years been in numerous cases brought into practical use, the first application of the system having been made in London, by Latimer Clark. That city now possesses the most complete arrangement of the kind. The very important traffic of the great commercial centre requires arrangements of a special description, which have been carried out with the greatest success by the engineer-in-chief of the post office, Mr. Culley, and by Mr. Sabine.

After London; Berlin, Paris and Vienna have successively adopted the new means of communication, and have laid down similar systems of tubes for the service of internal messages.

The favor which this new system, which cannot pretend to vie with electricity in point of capacity, has found, is owing solely to the peculiar conditions which arise in the majority of great cities, that is to say, that the telegraph service is, in such cases, called upon to transmit a large number of messages over distances comparatively very short. Under such circumstances, electricity is surpassed in speed by modes of transit whose action is much less instantaneous, but whose capacity for transmission is very much greater.

In order to render this rather abstract explanation more complete, I will take for example the case of a telegraphic wire having to transmit a certain number of messages over a distance of no more than one thousand meters, and I will compare with it a pneumatic tube performing a similar service. The wire will transmit the messages one by one, and it will not be able to send more than forty in an hour; a clerk must be employed at each end. By means of the tube the distance will be traversed in one minute, and a hundred messages can easily be carried; these messages can besides, be the actual manuscripts, can be secret, and the apparatus being only affected by the bulk and weight of the messages, no matter how many words may be contained in the message, the transmission is equally rapid, and but two attendants are required. The case cited above is one in

which the tube has a most incontestable advantage over the electric wire. It is easy to perceive that this advantage diminishes as the number of messages to be transmitted decreases, and it diminishes also as the distance which separates the two points increases. There arrives, therefore, a time when the wire regains the advantage; that is, when it is able to transmit all the messages which have to be forwarded in a shorter time than it would take the tube to convey them over the same distance.

This method of collecting and distributing messages in great cities gives excellent results in all cases where the traffic is considerable. The arrangements established in the different cities vary according to the method of working, but the principle is always the same, and may be summed up as follows: A tube, as perfectly round as possible, connects the two points which are to be placed in communication; one or more boxes (carriers) containing the messages are introduced into the tube by an apparatus the essential features of which are always the same; that is to say, the tube is closed behind, and a branch tube opening into the main tube between the end of the latter and the train (boxes or carriers), directs a current of compressed air into the tube, producing a pressure H greater than the atmospheric pressure h, which acts at the other end. It is under the influence of this difference of pressure, $H - h$, that the train is driven forward along the line, continually receding from the point at which the compressed air is introduced.

When a message has to be brought in the reverse direction, the same point is placed in communication with a reservoir, in which the pressure is less than the atmospheric pressure h, which acts at the other end. $H - h$ is now negative, and the train placed at the extremity of the line is drawn back to the original point of departure, where it arrives at the end of a certain time. The suction of air is then stopped by the simple closing of a stop-cock, and a door similar to that used for the sending, allows the train to be taken out of the tube. An electrical communication is provided, by means of which the attendants placed at the ends of the table are able to control and direct all their operations.

The method employed for compressing the air and producing the vacuum may be any one of the methods by which this class of work can be performed. It appears, however, after different trials, that

steam-engines, with direct-acting air-pumps have been found to work with the greatest regularity, and have consequently been adopted almost universally in cities possessing pneumatic telegraphs.

As regards the circulation, this is effected either by a circular network, worked continuously or alternately, according to the importance of the traffic, or by a radiating system worked in the same manner. In both cases pressure is used for impelling the trains forward, and vacuum for drawing them inwards. The radiating system seems to have been established at the commencement, as being the most simple, and it has been maintained where the traffic is very important, on account of its affording a service of the most direct character. The largest system of this kind is that of London, where special arrangements are made by which the tubes are traversed by continuous currents of air into which the boxes or carriers to be forwarded are introduced by means of a species of sluice, the boxes received being taken out as they arrive, by the same means. One of the first systems proposed for Paris, in 1860, by M. Antoine Kieffer, was arranged in the same way.

Pamphlet by M. Amédée Sebillot.—In 1866, when the first pneumatic lines were established in Paris, this system was not adopted, and the first works of the kind, executed in Paris by MM. Mignon and Rouart, were carried out upon the network principle, and worked by intermittent currents of messages at regular intervals, a mode of working which is more economical than the former, although rather less rapid.

After this short descriptive account, I come to the object of my paper. In the first place, I propose the following question:

What are the laws which regulate approximately the movement of boxes in pneumatic tubes?

Experiment shows that the presence or absence of the train in a tube has but little influence upon the flow of the air; that the flow takes place under conditions almost identical with those which govern the flow of other fluids, and that the laws which are observed to prevail in the case of these other fluids can, without risk of too much error, be applied to the particular case now under consideration.

Let R be the resistance to the movement, l the length, X the perimeter, u the speed, a and b coefficients; the approximate formula for the flow of fluids is—

$$R = l\,X\,(a\,u + b\,u^2)$$

Disregarding the term where the speed is in the first degree, the formula becomes—

$$R = b\,l\,X\,u^2$$

The force which causes the boxes to move, being equal to the difference of pressure $(H - h)$ multiplied by the section S upon which it is applied, the formula of the movement will be approximately—

$$(H - h)\,S = b\,l\,X\,u^2$$

which in the case where the section is a circle, becomes—

$$H - h = \frac{8\,b\,l\,u^2}{D} \therefore u = A\sqrt{\frac{(H - h)D}{l}}$$

A formula which numerous experiments have shown to be sensibly correct for the conditions under which pneumatic tubes are usually established and worked, and which shows that the speed varies as the roots of all the conditions of the case, directly for pressure and diameter, universally for length.

As we are considering the means to be employed in order to construct a line of a length l, as great as possible, let us examine successively the influence of each of the forces or dimensions which affect the speed under these conditions.

The first thing to examine is certainly the pressure, or rather the difference of the moving pressure $(H - h)$. The general formula shows that if we were to increase $(H - h)$ and l in the same proportion, a constant speed would be obtained.

Unfortunately, this simple solution is an impossible one, for the practical means at our disposal do not allow of air being compressed at a sufficiently low cost; beyond a certain limit, which is 1 effective atmosphere) or 2 atmospheres at most, the cost of compressing (owing to the great outlay necessary), is so considerable that if such a method of working were adopted, even supposing no obstacles were encountered from the elevation of the temperature and the moisture of the air, it would be impossible to organize a remunerative service. A limit would besides be quickly reached, for even by very costly processes, it is with the greatest difficulty that a pressure of from 5 to 6 atmospheres can be exceeded.

In the same way with vacuum. In continuous working, a vacuum of much more than 0·50 meters of mercury cannot be depended upon. In conclusion, a pneumatic line arranged for economical working

must not require a pressure of more than 2 atmospheres at most, nor a vacuum of more than 0·55 meters of mercury.

The second point to be examined is the diameter of the tube. Here it seems evident that no mechanical difficulty prevents a considerable increase; the formula shows that by increasing in the same proportion as the length, a constant speed will be obtained; experiment confirms this conclusion satisfactorily as regards the speed, and, in fact, the speed is generally found to exceed that shown by the formula. Unfortunately this plan would be too costly; it would result in the laying of very large tubes between points very far apart, even when the traffic between these points might be very small. Now, the cost of laying a pneumatic line increases very quickly with the diameter; much faster than the diameter, and the cost of working increases more quickly than the square of the diameter. It follows, from what has been previously stated, that, in laying a pneumatic line, the only point to be taken into consideration in fixing the diameter of the tube, is the amount of the traffic to be conveyed by it, and we shall see further on, that to accommodate an important traffic, it is not necessary to exceed a section which, at first sight, appears extremely small.

In examining arrangements of this nature, one is astonished at the small diameter of the tubes generally adopted; thus, in the great English system at St. Martin's-le-grand, the diameter of the tubes is almost exclusively $2\frac{1}{4}$ inches. Two lines only, the traffic of which is exceptional, and upon which up and down arrangements have been adopted, have been made 3 inches in diameter. The expenditure of air in these tubes is double that in the others, and consequently the English engineers have restricted their use as much as possible.

What is the reason for a size which at first sight appears so small? The answer will be found in examining the conditions under which the line itself is established.

A telegraph message or a pneumatic letter is always very limited in its size and weight, the amount of matter daily sent through pneumatic tubes by a population of one or two millions of inhabitants is represented by a bulk and weight far from great, and when the comparatively rapid speed with which this matter is passed through the tube is taken into consideration, it is easy to see that it is not at all necessary, in a successful system, for them to be of large dimensions.

Let us make a comparison between the tubes under consideration

and other mains or tubes carried underneath the soil in large cities for distributing gas and water, the latter of which, in well supplied towns is furnished to the inhabitants at the rate of about 100 liters per head per day. To afford this, supply mains of about a meter in diameter are employed on the chief routes, and of a smaller diameter on the others; the speed of circulation is at most one meter per second. In the case of the matter conveyed in the pneumatic tubes the amount certainly does not exceed 1 gram for each inhabitant, or one thousand times less, and the speed in the pneumatic tubes is at least ten times as great; with a section of one millionth, we shall then have made the conditions nearly equal.

If we apply these figures to Paris we find a mean circulation of 10,000 messages per day of 5 grams each, making a total weight of 50 kilograms: these messages distributed into boxes, for passage through the tubes, at the rate of 25 per box, would require 400 boxes or 40 boxes per hour, which could easily be forwarded in four trains dispatched at intervals of a quarter of an hour. It is clear that trains might be sent at much more frequent intervals provided, of course, that sufficient power were employed to produce the compressed air and vacuum which would be required.

The tubes employed in Paris have a diameter of 0·065 meters, and would certainly suffice for a traffic of 50,000 messages per day, if the need for carrying so large a number of messages arose.

(To be continued.)

PRODUCT OF SUGAR IN LOUISIANA.

The actual results from cultivation of sugar-cane in Louisiana are exemplified by the following statements:

On the plantation of Messrs. McCall Bros., there was raised from 569 acres of cane plantation, 15,961,384 lbs. of cane, or 28,051 lbs. per acre. The yield of cane juice averaged 7° to 8° Beaumé density and the product in sugar was 506,500 lbs.; in molasses was 516,000 lbs.; or 1000 bbls. of 43 gals. of 12 lbs. per gallon. Total weight, 1,022,500 lbs., equal to $6\frac{4}{10}$ per cent. of the cane worked.

On the plantation of Col. Amedée Bringier there was obtained from 51 acres of selected cane plantation, 2,947,500 lbs. of cane or 57,794 lbs. per acre. The yield of cane juice was 8° Beaumé, and the product

in sugar was 135,272 lbs.; in molasses 74,976 lbs.; total weight, 210,248 lbs., or 7·13 per cent. of the cane juice. The great preponderance of sugar over molasses in this case is ascribed, first, to the good condition of the cane, and secondly, to the superior treatment of the cane juice in the boiling processes; [but it should be added that the usual ratio of sugar to molasses in first strikes for Cuba or Beet-root practice is as 2 to 1 (of molasses of 12 lbs.)]

On Evan Hall plantation, of Harry McCall, Esq., was produced for the season of 1874–5, "7599 loads of canes weighing 22,294,670 lbs. The yield of cane juice was 1,417,800 gallons of a density of 7° to 8° Beaumé, (12,505,000 lbs). Evaporated to 25 per cent. Beaumé hot, the result was 274,000 gallons of syrup, (2,740,000 lbs.) Mr. McCall estimates the product of this to be (first strike only for New Orleans molasses is so valuable as to preclude making 2d or 3d sugars) 900,000 lbs. of sugars and 700,000 pounds of molasses." His estimates are shown in the following table:

Total of Saccharine of the density of Sugar.	First Sugar.	Molasses of 30° Beaume. 55 per cent. of Saccharine. 12 pounds per gallon.		Syrup of 25° Beaume. 46 per cent of Saccharine. 10 pounds per gallon.		Raw Juice of 7° to 8° Beaume. 13 per cent of Saccharine. 8·82 pounds per gallon.		Pounds of cane.	Product of cane.
Lbs.	Lbs.	Lbs.	Galls.	Lbs.	Galls.	Lbs.	Galls.	Lbs.	Acre.
5·80	4·05	3·15	0·26	12·15	1·22	55·	6·22	100·	
1·43	1·	0·78	0·065	3·	0·3	13·6	1·54	24·7	
4·77	3⅓	2·6	0·22	10·	1·	35·3	5·13	82·3	
	1134		70·8		341·6		1741·6	28,000.	1

[The estimates of this table are scarcely compatible with each other, and indicate some want of care in taking the density of the raw juice or great loss of density in defecation and skimming. 55 lbs. of raw juice of 7½° Beaumé density ought to give 16·1 lbs. of syrup of 25° Beaumé, or not less than 15·9 lbs. with a large allowance for

skimmings. 12·15 lbs. of syrup of 25° Beaumé ought to give 4·05 lbs. of sugar, and only 2·8 lbs. of molasses of 12 lbs. per gallon. As the result is *estimated*, it is impossible to correct the densities from it, but it is probable that the syrup was boiled to 27° or 28° Beaumé, and that the raw juice was about 6½° on the average.]

There was consumed in working off this crop on the Evan Hall plantation, 8600 barrels coal and 800 cords of wood. (These quantities do not reduce themselves to common units of value in any satisfactory way.)

Mr. McCall states in reply to the question, "How much it costs to cultivate an acre of cane?" "It is very difficult to give a satisfactory answer. Inasmuch as to raise cane, we are obliged to rotate with corn and peas, and each acre of cane, besides this year's cultivation, represents earlier work. As nearly as it can be come to, it can be said that it costs $80 per acre, all cultivation thrown in. As to what it costs to lay down a ton of cane in the shed, that is also difficult to state. Perhaps, however, in saying it costs $4 per ton we should not be much out of the way."

Of the present condition of sugar raising it can be said that, while in former times 10 hhds. (1150 lbs. each) were reckoned to a farm hand, since the war, 5 hhds. to the hand have rarely been exceeded. As a basis of estimate for the profit of the cultivation of cane it can be assumed that a good hand can easily cultivate 10 to 12 acres a year which should yield ¾ to 1 hhd. of sugar.

ON A SIMPLE METHOD OF COMPARING TWO SOUNDING AIR COLUMNS BY MEANS OF VIBRATORY FLAMES.

By Dr. Bresina.

(*Translated from Poggendorf's Annalen by C. B. Dudley, Ph. D.*)

The comparison of the vibrations may be accomplished, as is well known, by means of the apparatus constructed by Konig, in Paris. In this, two organ pipes act on two gas flames, one above the other, by means of manometric capsules. The motions of these flames are then analyzed by a rotating mirror.